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REPORT
No. 98-65

AUTHORIZING APPROPRIATIONS TO THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION FOR FISCAL YEAR 1984

APRIL 15, 1983.—Committed to the Committee of the Whole House on the State of the Union and ordered to be printed

Mr. FUQUA, from the Committee on Science and Technology, submitted the following

REPORT

together with

ADDITIONAL VIEWS

[To accompany H.R. 2065]

The Committee on Science and Technology, to whom was referred the bill (H.R. 2065) to authorize appropriations to the National Aeronautics and Space Administration for research and development, construction of facilities, and research and program management, and for other purposes, having considered the same, report favorably thereon with amendments (shown in italic in the bill accompanied by this report) and recommends that the bill, as amended, do pass.

The amendments are as follows:

Page 2, line 4 strike out "$1,979,400,000" and insert "$1,999,400,000" in lieu thereof.

Page 2, line 7 strike out "$521,600,000" and insert "$566,600,000" in lieu thereof.

Page 2, line 8 strike out "$215,400,000" and insert "$220,400,000" in lieu thereof.

Page 2, line 10 strike out "$311,000,000" and insert "$306,00,000" in lieu thereof.

Page 2, line 13 strike out "$300,300,000" and insert "$311,600,000, of which $20,000,000 is authorized only for activities in the Ad-

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vanced Turboprop program which are designed to lead to a flight test no later than 1987".

Page 2, line 14 strike out "$148,000,000" and insert "$143,000,000" in lieu thereof.

Page 3, strike out lines 1, 2, and 3 and insert in lieu thereof the following:

> (B) Modifications to mobile launch platform, John F. Kennedy Space Center, including exercise of contract option to preserve launch umbilical tower (LUT), $29,120,000; and

Page 4, in line 18 strike out the period and insert in lieu thereof a colon, and after and below line 18 insert the following:

> *Provided,* That the total amount authorized to be appropriated by this subsection shall be $5,000,000 less than the sum of the amounts contained in paragraphs (1) through (15) for individual projects.

Page 4, line 20 strike out "$1,247,500,000" and insert "$1,242,500,000" in lieu thereof.

Page 10, line 14 strike out in lieu thereof "fleet" and insert "fleet, as well as provisions for maintaining production readiness for a fifth orbiter vehicle."

Page 11, strike out lines 18 through 22.

Page 11, line 23 strike out "103(l)" and insert in lieu thereof "103(1)".

Page 12, after line 3 add a new Section 109 as follows:

> SEC. 109. Notwithstanding any other provision of law, there shall be transferred to NASA three government-owned tracts of NASA-used land and improvements thereon (totalling approximately 33.5 acres) at Ellington Air Force Base, Texas, without any transfer of funds therefor.

and renumber the succeeding section.

Page 12, after line 6 insert "TITLE II".

Page 12, strike out line 24 and lines 1 and 2 on Page 13 and insert in lieu thereof the following:

> a comprehensive statement of recommended policies, procedures, conditions, and limitations to which any transfer should be subject; and
>
> (2) the Congress thereafter enacts a law which contains such policies, procedures, conditions, or limitations (or a combination thereof) as it deems appropriate for any such transfer.

PURPOSE OF THE BILL

TITLE I

The purpose of title I is to authorize appropriations to the National Aeronautics and Space Administration for fiscal year 1984 as follows:

Programs	Authorization fiscal year 1984	Page No.
Research and development	$5,886,800,000	25
Construction of facilities	138,920,000	171
Research and program management	1,242,500,000	191
Total	$7,268,220,000	

TITLE II

The purpose of title II is to authorize appropriation of $29,336,000 for the National Oceanic and Atmospheric Administration to operate a land remote sensing system and to provide for limitations on the operation of the system.

CONTENTS

Page
Committee actions 7
Language amendments 12
Committee views 15
Explanation of the bill 25

TITLE I

Research and Development:
- 1. Space transportation capability development 25
  - Shuttle production and capability development 30
  - Upper stages 38
  - Spacelab 39
  - Engineering and technical base 41
  - Payload operations and support equipment 42
  - Advanced programs 43
  - Tethered satellite system 44
- 2. Space transportation operations 45
  - Flight operations 46
  - Flight hardware 48
  - Launch and landing operations 49
  - Delta 50
- 3. Physics and astronomy 51
  - Space telescope development 52
  - Gamma ray observatory development 53
  - Shuttle/Spacelab payload development and mission management.. 54
  - Explorer development 56
  - Mission operations and data analysis 57
  - Research and analysis 58
  - Suborbital programs 61
- 4. Planetary exploration 64
  - Galileo development 66
  - Venus radar mapper mission 67
  - International Solar Polar Mission 68
  - Mission operations and data analysis 69
  - Research and analysis 70
- 5. Life sciences 72
  - Life sciences flight experiments 74
  - Research and analysis 75
- 6. Space applications 78
  - Solid earth observations program 78
  - Environmental observations program 84
  - Materials processing in space program 95
  - Communications program 98
  - Information systems program 102
- 7. Technology utilization 103
  - Technology dissemination 104
  - Technology applications 105
- 8. Aeronautical research and technology 105
  - Research and technology base 106
  - Systems technology programs 121
- 9. Space research and technology 130
  - Research and technology base 132
  - Systems technology programs 148
  - Standards and practices 149

Research and Development—Continued

Page
10. Tracking and data aquisition program ... 151
Space network ... 152
Ground network ... 155
Communications and data systems ... 162
Advanced systems ... 167

Construction of facilities summary:

1. Space Shuttle facilities at various locations as follows:
A. Modifications for additional chillers for Mission Control Center; Lyndon B. Johnson Space Center ... 174
B. Modifications to Mobile Launch Platform No. 3; Kennedy Space Center ... 175
C. Modifications to the manufacturing and final assembly facilities for external tanks; Michoud Assembly Facility ... 177
2. Construction and modification to Space Shuttle payload facilities:
A. Construction of cargo hazardous servicing facility; Kennedy Space Center ... 179
B. Modifications to spacecraft assembly and encapsulation facility (SAEF-2) for cargo proccessing; Kennedy Space Center ... 179
3. Construction and modifications at the Jet Propulsion Laboratory:
A. Construction of frequency standards laboratory ... 180
B. Modifications to space flight operations facility ... 180
4. Construction of fluid mechanics laboratory; Ames Research Center ... 181
5. Construction of aeronautical tracking facility; Dryden Flight Research Facility ... 182
6. Modifications to Langley Research Center:
A. Modifications and addition for composite materials laboratory (1293A) ... 182
B. Modifications to 30-by-60-foot tunnel (643) ... 183
7. Modifications to Lewis Research Center:
A. Modifications for small engine component testing facility ... 184
B. Modifications to icing research tunnel ... 185
8. Relocation of 26-meter STDN antenna, Spain ... 185
9. Repairs of facilities at various locations ... 185
10. Rehabilitation and modification of facilities at various locations ... 187
11. Minor construction of new facilities and additions to existing facilities at various locations ... 188
12. Facility planning and design ... 188
Research and program management ... 191
Title II: NOAA Landsat Authorization ... 198
Sectional Analysis ... 199
Cost and budget data ... 203
Effects of legislation on inflation ... 204
Changes in existing law made by the bill as reported ... 204
Oversight findings and recommendations ... 205
Congressional Budget Act information ... 205
Estimate and comparison, Congressional Budget Office ... 205
Oversight findings and recommendations, Committee on Government Operations ... 206
Committee recommendations ... 206
NASA recommendations ... 206

Additional views:

Hon. Al McCandless ... 208
Hon. Dan Glickman ... 209
Hon. William Carney ... 210
Hon. Bill Nelson, Manuel Lujan, Jr., Bob Walker, William Carney, Raymond J. McGrath, Joe Skeen, Claudine Schneider, Herbert H. Bateman, Alfred A. McCandless and Tom Lewis ... 211

COMMITTEE ACTIONS

TITLE I

RESEARCH AND DEVELOPMENT

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT

NASA requested $1,927,400,000 for space transportation capability development activities in fiscal year 1984. The Committee increased funding for shuttle production and capability development by $70,000,000; decreased funding for engineering and technical base by $8,000,000; and increased funding for advanced programs by $10,000,000 resulting in a total recommended authorization of $1,999,400,000 in fiscal year 1984.

Shuttle production and capability development. NASA requested $1,500,000,000 for shuttle production and capability development activities in fiscal year 1984. Within this program, the Committee (1) added $60,000,000 to increase orbiter structural spares, to preserve critical orbiter component subcontractors, to maintain critical skills, and to maintain production readiness for a fifth orbiter vehicle and (2) $10,000,000 to increase funding for engine spares resulting in a total recommended authorization of $1,570,000,000 for shuttle production and capability development activities in fiscal year 1984.

Engineering and Technical Base. NASA requested $93,100,000 for engineering and technical base activities in fiscal year 1984. The engineering and technical base funding provides the core capability required to sustain an engineering and development base for various space transportation system activities. With completion of the development program the committee suggests increasing the involvement of in-house civil service manpower in these activities and therefore recommends a decrease of $8,000,000 resulting in a total authorization of $85,100,000 in fiscal year 1984.

Advanced Programs. NASA requested $15,000,000 for advanced programs to provide technical and programmatic data for the definition and evaluation of candidate future space flight programs. The Committee fully supports NASA ongoing definition and evaluation studies related to a permanent manned space station. The Committee increased funding in this area to continue industrial involvement and to assure that alternative concepts and evolutionary approaches are considered. A total increase of $10,000,000 was adopted for space station contractor studies, for alternative concept studies, and for studies and advanced technical development of an unmanned space platform which would be serviced and supported by the space shuttle orbiter with an extended orbit duration capability of 30 to 45 days resulting in a total recommended authorization of $25,000,000 for advanced programs in fiscal year 1984.

The current budget request includes $6 million for space station in-house studies with no plans to continue the current ongoing complementary industry studies. The increase recommended by the Committee would provide an additional $6,000,000 to continue industry involvement in mission analysis and systems definition activities and to assure that private sector uses and commercial applications are fully considered.

The current mission analysis studies being conducted by NASA are focused on a manned space station. Any future decision on a space station will need to consider whether or not there are alternative approaches to the manned space station which could accomplish the same mission requirements. Therefore, $2,000,000 was included to specifically fund studies which would identify alternative approaches.

One evolutionary approach which has been identified involves unmanned space platforms supported and serviced by the space shuttle orbiter with an extended orbit duration capability of 30 to 45 days. Within the increase recommended, $2,000,000 was provided for in-house and contractor definition and evaluation studies of this approach.

PHYSICS AND ASTRONOMY

NASA requested $514,600,000 for Physics and Astronomy programs in fiscal year 1984. The Committee recommended an increase of $45,000,000 for the space telescope program, $6,000,000 for research and analysis activities and $1,000,000 for missions operations and data analysis resulting in a total recommended authorization of $521,600,000.

NASA requested $120,600,000 for the Space Telescope development and the Committee recommends an increase of $45 million to a total of $165,600,000. The additional funding is necessitated by development problems which have arisen, the resolution of which will require additional spares and additional fixtures, components, and equipment for testing purposes.

Research and Analysis. NASA requested $29,800,000 for research and analysis activities in fiscal year 1984. The Committee recommended an increase of $6,000,000 including $4,000,000 to augment basic research programs—theoretical and experimental research programs at universities which interpret and disseminate the results of flight missions, and $2,000,000 for research instrumentation at universities to maintain and stimulate basic research in support of NASA science missions.

Mission Operations and Data Analysis. An increase of $1,000,000 is for the Mission Operations and Data Analysis program to support analysis of HEAO-11 data. This satellite has ceased operating but a great deal of data remains to be analyzed. The user community for this date, X-ray astronomers, is the same community that will use data provided by the Advanced X-Ray Astronomy facility, the next major new start recommended by the Astronomy Survey Committee. Thus, this increase will help maintain the scientific base for such a mission.

PLANETARY EXPLORATION

NASA requested $205,400,000 for planetary exploration programs in fiscal year 1984. Within this line item the Committee increased the budget request for research and analysis activities by $15,000,000 to $60,500,000 resulting in a total recommended authorization of $220,400,000 for planetary exploration.

The primary users of data generated by planetary missions are research scientists working in universities. In recommending this addition the Committee is taking a step toward rebuilding the university planetary research community which has been impacted by cuts since fiscal year 1981. For purposes of comparison, to provide the purchasing power that was available in fiscal year 1981 would require a budget level of $72 million in fiscal year 1984 dollars.

The Committee is encouraged that the request includes funds to initiate the Venus Radar Mapper mission and that the Mission Operations and Data Analysis request is adequate to keep all existing spacecraft operating.

However the Research and Analysis budget request represented a reduction of 9.5 percent from fiscal year 1983 (down $5 million to $45.5 million). The requested level of funding would result in an adverse impact on supporting research in areas such a planetary geology, planetary atmospheres, and geochemistry. The recommended increase would not only augment these supporting programs but would also support non-Voyager Jupiter/Saturn data analysis and definition studies for the next generation of planetary missions such as the Mars Geochemical Orbiter, a Comet Rendezvous, and a Titan Probe, which have been recommended by the Solar System Exploration Committee.

SPACE APPLICATIONS

NASA requested $284,000,000 for Space Applications Programs in fiscal year 1984. Within this line item the Committee recommended increases of $9,000,000 in Solid Earth Observations; $3,000,000 in Environment Observations; and $5,000,000 for Materials Processing in Space. Therefore, the total recommended authorization for Space Applications is $306,000,000.

Solid Earth Observations. NASA requested $74,400,000 for this program in fiscal year 1984 and the Committee recommended an increase to $83,400,000. The recommended increase would be for three distinct items. An increase of $4,000,000 is recommended for Research and Analysis to support applications studies related to space-borne radars and the Global Resource Information System. NASA is flying sophisticated radars aboard the Shuttle (SIR–A, SIR–B) that will generate large amounts of data. The Committee intends that part of this increase be used to turn this radar data into useful information and to develop and verify techniques for using spaceborne radars, e/g., for geological prospecting.

The concept of a Global Resource Information System (GRIS) was developed in a 1981 Committee report of U.S. Civil Space Policy which requested NASA to prepare a plan for GRIS. The plan was submitted in February 1983, and seems to emphasize the computer hardware aspects of such a system. As there appears to be no funding for GRIS in the 1984 request, the Committee intends that $1 million of this increase be applied to study the uses to which a GRIS could be put, and the way that it could be most accessible to users. The increase is put into this program element rather than into Information Systems to emphasize that the purpose is not hardware design but user-involvement.

An increase of $2,000,000 would partially restore the OMB reduction of NASA's request for AgRISTARS. The apparent lack of a commercially viable market for LANDSAT data illustrates the need for the government to continue to develop these applications. The same general argument applies to the recommendation that an additional $3,000,000 be added into the budget for Technology Transfer activities, specifically for tests to verify and demonstrate the validity and usefulness of space application systems.

By this action the Committee does not authorize and directs that no funds be used for, the Western Regional Evaluation and Test Experiment projects developed by Ames Research Center.

Environmental Observations. NASA requested $163,000,000 for this program in fiscal year 1984 and the Committee recommends an increase to $166,000,000. The addition of $3,000,000 for space physics includes $2 million for advanced technology development and experiment definition efforts by university research teams participating in the Origin of Plasmas in the Earth's Neighborhood (OPEN) program as well as $1 million to support a study to be conducted by the National Research Council on Sun-Earth interactions. The study is explicitly requested and described in the section of Committee Views on Space Application.

Materials Processing. NASA requested $21,600,000 for this program for fiscal year 1984 and the Committee recommended an increase to $26,600,000. The Committee recommends that $5,000,000 be added to this program for two purposes: the Committee believes that an area of great potential is the space-borne separation and purification of organic chemicals, i.e. pharmaceuticals. Therefore this increase should be used in part to establish at a university a center for basic research in the separation and purification of organics. In addition the Committee recommends an augmentation of research to be conducted through or in cooperation with private commercial firms with a view toward commercial applications of space processing. The Committee recommends that the Agency not put substantial additional resources into hardware until it has a better-defined sense of direction for this program.

TECHNOLOGY UTILIZATION

NASA requested $4,000,000 for Technology Utilization programs in fiscal year 1984. The Committee recommends an increase of $6,000,000 which would restore reduction made by OMB resulting in a total authorization of $10,000,000.

The Administration has again proposed a reduction in this program the purpose of which is to make NASA-developed technology available to a broad spectrum of industry in spite of repeated Congressional actions to maintain it at a higher funding level. The fiscal year 1983 funding was $9 million as a result of a $5 million Congressional augmentation.

The Committee recommends that the increase be used to continue support for activities of all the Industrial Applications Centers and all the State Technology Applications Centers, and to augment and initiate "applications team" efforts in rural, robotic, and bioengineering areas. In particular the Technology Applications Center in Albuquerque should continue to be fully supported to carry out its activities with regard to remote sensing applications.

Prompt Reporting of Inventions and Innovations. The Committee notes with approval NASA's continuing efforts to obtain prompt reporting of both inventions and innovations, whether or not patentable, under section 305(b) of the National Aeronautics and Space Act of 1958 as amended. This reporting is an important element of the Technology Utilization Program, and, consonant with its actions increasing the authorization for Technology Utilization programs, the Committee directs NASA to continue these efforts to assure that new technology is made available expeditiously to potential users.

AERONAUTICAL RESEARCH AND TECHNOLOGY

NASA requested $300,300,000 for Aeronautical Research and Technology. This amount represents an increase of 7.2 percent over the Fiscal Year 1983 appropriation.

The Committee feels that the aggregate amount requested by NASA is responsive to the thrust of the Administration's recent policy statement on aeronautical R&T, while at the same time recognizing the need for overall fiscal restraint. Upon close examination, however, the request shows clear evidence of further withdrawal from certain important technology validation activities with civil application that the Congress strongly supported in the past.

The Committee is also concerned with maintaining a proper balance between in-house and contracted work and between applied research and technology validation. In both instances, the program must contain a meaningful component of the latter—that is, both contracted work and technology validation activities—to maximize the transfer of research results into useful applications. The proposed Fiscal Year 1984 program moved away from balance in this regard.

Accordingly, the Committee recommends an increase of $11.3 million, bringing the total authorization to $311.6 million. Within this amount, $20 million is authorized only to restore activities in the Advanced Turboprop Program which are designed to lead to a flight test no later than 1987. The Committee also recommends the following additional restoration to the civil systems technology area: $14.0 million to be applied at NASA's discretion to upgrade the Advanced Transport Operating Systems, completion of the presently defined Laminar Flow Control Program, continuation of the Small Engine Component Technology Program, and start of the Advanced Turbofan Research Program. To offset these restorations, the Committee further recommends a general reduction in the R&T base of $22.7 million.

The Committee is strongly in favor of proceeding as rapidly as possible with development of the Numerical Aerodynamic Simulator with the full funding as proposed by the Administration. The

Committee also applauds NASA's new initiative in the composite materials area, but would urge expansion of this program to include fundamental work on advanced metals.

SPACE RESEARCH AND TECHNOLOGY

The NASA budget request for fiscal year 1984 included $138,000,000 for space research and technology activities. This program provides a technology base to support the conception and design of advanced space systems and to explore technology which will reduce the cost of space operations. The Committee recommends an increase of $2,500,000 for university research instrumentation and laboratory equipment and an increase of $2,500,000 to augment advanced chemical propulsion technology to support high-performance, long-life propulsion systems for orbital transfer vehicles; resulting in a total recommended authorization of $143,000,000 in fiscal year 1984.

CONSTRUCTION OF FACILITIES

NASA requested $150,500,000 for construction of facilities activities in fiscal year 1984. Within this amount NASA requested $8,400,000 for reimbursement to the General Services Administration in exchange for the transfer of real properties at Ellington Air Force Base, Texas, to NASA Johnson Space Center. The Committee authorized transfer of this property which includes facilities that are primarily used for astronaut training such as aircraft hangers, warehouses, support buildings, and utilities required to support aircraft operations. However, the Committee deleted the $8,400,000 from the budget request since the transfer can be implemented with no exchange of funds. The Committee further recommended a general reduction of $5,000,000 and an increase of $1,820,000 to preserve an Apollo launch umbilical tower resulting in a recommended authorization of $138,920,000 for construction of facilities in fiscal year 1984.

RESEARCH AND PROGRAM MANAGEMENT

NASA requested $1,247,500,000 for the Research and Program Management account in fiscal year 1984. The Committee believes that this amount can be reduced by $5,000,000 without undue impact on the conduct of the agency's programs. Therefore, the Committee recommends an authorization of $1,242,500,000.

LANGUAGE AMENDMENTS

Section 106

The Committee amended a new Section 106 which was proposed by NASA to clearly show the Committee's intent that NASA maintain production readiness for a fifth orbiter vehicle. The Committee added at the end of Section 106 the following "as well as provision for maintaining production readiness for a fifth orbiter vehicle".

Section 107

The Committee adopted a new Section 107 as amended which was proposed by NASA to amend Title III of the National Aeronautics and Space Act of 1958, as amended, by adding at the end thereof a section regarding "Misuse of Agency Name and Initials".

Section 108

The Committee adopted a new Section 108 which would amend Section 103(1) of the National Aeronautics and Space Act of 1958, as amended, to include "operation of the space transportation system" within the definition of the term "aeronautical and space activities".

Title II

The Committee adopted and amended a new Title II which would authorize funds to NOAA for operating the land remote sensing satellite system and would prohibit the transfer of weather and land satellites to the private sector until certain actions are taken by the Secretary of Commerce and the Congress. The Secretary is to submit to the Congress a comprehensive statement of recommended policies, procedures, conditions, and limitations to which any transfer should be subject. The transfer cannot take place until the Congress thereafter enacts into law such policies, procedures, conditions, and limitations as it deems appropriate for any such transfer. The intent of the amendment is to ensure early, formal Congressional involvement in setting the course for a possible transfer of the remote sensing satellite systems to the private sector while reserving final Congressional approval for any proposed transfer.

COMMITTEE VIEWS

U.S. CIVILIAN SPACE POLICY

There has been a great deal of public discussion in the past year regarding the activities of the United States in space. Much of this discussion has centered around three main issues: the interface between the civilian and military uses of space, the commercialization of space, and the lack of focused long-range goals.

In regard to the first issue, the National Aeronautics and Space Act of 1958 provides for the establishment of a civilian agency, separate from the military, to conduct the aeronautical and space activities of the United States Government. However, the Act also provides for independent civil and defense programs to share information and technology; share launch vehicles; and where appropriate, operate cooperative programs. At issue, is not the basic concept of sharing, but the degree of participation by NASA in activities beneficial to DOD.

NASA's involvement in "dual-role" technologies is most apparent at the opposite ends of its spectrum of activities namely; space research and technology and launch operations. The fundamental character of NASA's space research and technology program, in most cases, leads to advances in technology that are applicable to both civil and military applications. For example, NASA estimates that 85 percent of its fiscal year 1984 space research and technology budget request would contribute to potential military as well as civilian applications. At the other end of the scale, DOD is a major user of the NASA-developed Space Transportation System.

It can be seen from these illustrations that NASA plays as important, if subsidiary, role in national defense. However, any expansion of that role would run the risk of compromising the open nature of our civil space program and should be vigorously resisted. Although NASA cannot be divorced completely from national security activities, adherence to the policies of the Space Act requires that NASA's participation in these activities be limited.

On the second major issue, space commercialization, there are two general areas of concern. The first is, how to transfer existing space systems? The second is, what institutional mechanisms are needed to allow for smoother transitions from Government to industry in the future? Although the stated Administration policy is to encourage the private sector to become more involved in space activities, no comprehensive principles, guidelines, or institutional frameworks have been provided. Appropriate roles and cooperative approaches for the public and private sectors must be defined more clearly.

The third main issue is the lack of long-range civil space goals. Since the Apollo program, there has been no clear objective that the Nation could focus on and identify with. Long-range planning or goal setting is required to balance the numerous space program possibilities and opportunities against each other and against other existing national needs. Out of this balancing a program direction could be chosen which would be in the best interest of the Nation. Establishment of long-range goals would provide a better sense of direction and commitment to guide programmatic decisions through year to year budget decisions. The absence of long-range goals results in short-term policies which change too often to allow for a cohesive, rational view of our future direction and purpose in space.

COMMERCIALIZATION OF SPACE

The Space Shuttle has ushered in a new era in the United States' space program by providing a unique and powerful space transportation capability. This capability has been made possible through the expenditure of public funds and the public trust must be protected as we move ahead with the commercialization and industrialization of space.

As the commercial opportunities offered by space exploration evolve, a new policy must be forged that provides opportunities for the American free enterprise system to use space for a variety of applications and technologies. We must assure that the strengths of free enterprise are extended to space activities, i.e. freedom of private business to organize and operate for profit in a competitive system. We should establish a policy which would encourage commercialization of space technology to the maximum extent feasible.

The Committee intends to meet this challenge and in a responsible manner address the total issue of commercialization of space by initiating intensive hearings on the subject. Sufficient time for all interested parties to participate and make a contribution will be allowed, with the intention of providing a forum for meaningful dialogue on all facets of the issue. Aerospace industry executives and entrepreneurs will be invited to air their ideas on the direction that this Nation should take in formulating a space commercialization policy.

The first and foremost goal of the Committee will be to act in the best interest of the United States, and we look forward to these hearings in the belief that they will provide guidance and scope to this most important issue.

SPACE TRANSPORTATION SYSTEM

The development of the Space Transportation System with the space shuttle as the centerpiece has established a new national resource which should be fully exploited to serve the needs for civil government, national security, commercial, and foreign users. However several uncertainties and unresolved issues strengthen the position of competitive foreign launch systems. These include the shuttle flight rate capability including adequacy of the orbiter fleet, the possible unavailability of expendable launch vehicles, and OMB's assertion that the government should not provide a launch capability greater than that needed to satisfy government uses. These uncertainties increase the potential that commercial customers face a high probability of being "bumped" from planned Shuttle flights and threaten future access to space for commercial users. NASA should assume a leadership role in resolving these uncertainties and in assuring that launch services are available for government and commercial customers. Additionally, NASA should seek greater participation by the private sector in shuttle marketing activities.

Orbiter Fleet Size. The Committee continues to believe that additional orbiters beyond the currently planned four will be needed to accomplish civil, commercial, and defense missions; to provide flexibility for exploitation of the shuttle's capabilities through increased on-orbit power and mission life; and to provide adequate backup to the currently planned fleet.

Expendable Launch Vehicles. The Committee believes that maintenance of expendable launch vehicle capability, until the Shuttle flight capability can fully satisfy civil, commercial, national security, and foreign requirements, is in the best interest of the United States. The development of the Shuttle Space Transportation System has established a new national resource for scientific, national security, and civil application. Maintaining a balanced set of alternative launch capabilities during the early operational portion (1983–1990) of this new operational system will assure that space program assets developed during the past twenty-five years are fully utilized. Therefore, NASA is requested to submit to the Committee by September 1, 1983, a plan for maintenance of expendable launch vehicle capability in support of the new space transportation system. This plan shall include, but not be limited to, specific recommendations to allow U.S. expendable launch vehicles to be competitive with foreign launch vehicles and should include appropriate recommendations to facilitate commercial ventures.

Space Shuttle Marketing. Technical evolution of the space shuttle has progressed sufficiently such that the development of the full potential for marketing the system needs to receive senior NASA management attention. The Committee believes that NASA should use the expertise of the private sector to develop an effective marketing approach. Effective marketing of space shuttle capabilities to commercial and foreign customers should serve to decrease the government's share of operational costs and assure that the shuttle system achieves the full potential for which it was developed. Therefore, NASA shall communicate to the Congress at the earliest practicable time but not later than October 1, 1983, both short and long term plans to establish an effective private sector space shuttle payload marketing activity.

SOLID ROCKET BOOSTER REFURBISHMENT ACTIVITIES

The Committee is concerned about the progress being made on the Solid Rocket Booster Refurbishment Program in providing facilities, tooling, and procedures for these operations. In testimony, NASA has identified a current flight rate capability of 16 solid rocket booster sets per year with a goal of achieving 24 sets per year. For more than a year the Committee has been aware that

NASA does not have a comprehensive plan for solid rocket booster refurbishment activities which is the most significant known obstacle to achieving a flight rate capability of 24 flights per year. The Committee has two concerns. First, that time is running out in establishing the necessary provisions for achieving 24 sets per year by 1987. Second, that manufacturing operations are much different than the development of limited quantities of flight hardware and that, as such, NASA may not be totally familiar with the nuances of production operations. Accordingly, the Committee requests that NASA submit a comprehensive manufacturing plan for the Solid Rocket Booster Refurbishment activities which describes features such as incoming materials inspection techniques, tooling required, environmental building standards, material handling, thru-put scheduling, pesonnel selection and training, anticipated yield, component procurement, "gating" work tasks, management techniques (including computer support) and which outlines detailed schedules and milestones for achieving a refurbishment capability of 24 sets per year.

SPACE TELESCOPE

The Committee is very concerned about the current technical and management problems which are being experienced with the Space Telescope development program. The schedule slip of six months and cost growth of $100 million which were discussed in February hearings is now assessed as a schedule slip of more than a year with a cost growth of more than $200 million. The Committee recognizes the technical challenge of the Space Telescope development but believes that increased management focus at NASA headquarters, the cognizant field center, and at the contractors together with increased efforts on resource estimating will serve to bring these problems under control.

The Committee is also concerned that reprogramming of additional resources in fiscal years 1983 and 1984 for the Space Telescope from within space science and applications will result in further damage to the already constrained supporting research and technology activities. The Committee encourages NASA to request any additional funds which are required through the normal Congressional budget authorization and appropriation process.

PLANETARY EXPLORATION

The Committee fully supports a national commitment to a healthy, vigorous planetary exploration program. Planetary exploration contributes not only to our understanding of the Earth and its place in the universe but is also at the leading edge of our efforts to advance high technology. By studying other planets—their weather, their atmosphere, their chemistry, their geology—we learn more about the Earth. The accomplishments of our unmanned Viking landings on Mars and the Voyager missions to the outer planets have not only captured the interest and imagination of millions of Americans but demonstrated to the world our technological leadership.

Requirement for Technology Development. The Committee action in supporting a forward-looking planetary program—i.e. building support for a vigorous research community—indicates a desire to see a balanced program of missions to the inner and outer planets. Indeed the Solar System Exploration Committee has made similar recommendations. The Committee notes that execution of such a program requires appropriate technology, and in particular that non-solar power sources will be needed for future missions to the outer planets. Therefore, the Committee requests that the Agency take the following two steps: (1) That the Agency report promptly on the status of long term plans for technology development (including power sources) for deep space missions beyond Galileo and ISPM. (2) That the agency request that the NASA Advisory Council, acting through its appropriate subgroups or combinations thereof, promptly initiate a review of the adequacy of current Space Research and Technology programs for supporting future planetary missions, and report the results of that review to the Committee by January 1, 1984.

Infrared Telescope Facility in Hawaii (IRTF). The Committee continues to support NASA involvement in ground based research facilities and in IRTF and reiterates the position it expressed in the report accompanying last year's authorization bill (House Report No. 97-502):

> A research facility such as the Infrared Telescope Facility cannot operate efficiently when funding crises occur every fiscal year. Therefore, the Committee directs NASA to continue support for the Infrared Telescope Facility until an interagency agreement between NASA and NSF is completed which provides for NSF support of the facility, or until an independent, outside, scientific peer review finds that the facility should be closed.

SPACE APPLICATIONS

Space Act Mandate. The National Aeronautics and Space Act of 1958 provides that NASA shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof. The Committee urges increased efforts to improve NASA's ability to assist users and potential users of space technology. The Committee continues to support and encourage the Agency in what might be called "follow-through" activities. It is not enough merely to develop a technology or to fly a mission; the user community must be involved from the beginning in planning applications programs. The technology must be put to use and the justifying objectives of a mission must be reached. In the Applications programs (as in the Science programs) technologies and missions are not ends but means. The final objective is to use a space technology or mission "for the benefit of all mankind". The Agency should always be conscious of the use to which a technology will be put—or the use that scientists will make of data from a mission. Thus the Committee believes that both formally identified and indirect technology transfer programs must be continued, and that adequate support must be maintained for research communities that analyze the scientific data from missions. It is through this follow-through support, which is often at a relatively small cost, that the Agency can maximize the benefits of the technology which is developed.

Programs to develop, verify, and disseminate remote sensing applications seem to be relatively underfunded, i.e. Technology Transfer was eliminated in FY 1983, and the current budget request, if left unchanged, would eliminate the NASA involvement in AgRIS TARS in FY 1984. The Committee is concerned that the Agency is withdrawing into the engineering and technology activities with which it is most comfortable while neglecting needed efforts focused on overcoming barriers to achieving larger benefits for broader segments of society.

Study of Sun-Earth Interaction. Many in the scientific community believe that a better scientific understanding of Sun-Earth interaction would contribute significantly to the solution of many global scientific problems. The inadequate funding for the Origin of Plasmas in the Earth's Neighborhood (OPEN) mission as well as the delay of the Upper Atmosphere Research Satellite (UARS) and the cancellation of the U.S. part of the International Solar Polar Mission (ISPM) all seem to indicate a lack of appreciation on the part of the Agency of the importance of Sun-Earth interactions. The Sun and its dynamics affect weather, climate, oceans and communications on Earth. Part of the reason for the lack of appreciation appears to be that the scientific community is split into factions—solar physicists, space-plasma physicists, meteorologists, stratospheric researchers, climatoligists, and others. Yet the various phenomena are related and are often of critical and immediate economic importance on Earth. For this reason, the Committee has recommended an increase of $1 million for a study, to be conducted through the National Research Council of the National Academies of Science and Engineering, of the scientific connections and importance of Sun-Earth interactions.

The study should lay out these interactions and their scientific and practical importance, and building on this base, develop a plan for Federal research (both basic and applied) in this area. In this latter respect the report of the Astronomy Survey committee might be a useful model.

The Committee would expect that the center-of-gravity of this study would lie with the Space Science and Space Applications Boards of the NAS and NAE, but emphasizes that other Academy groups would have to be brought into the study—for example the Climate Research Board and the Committee on Atmospheric Sciences. In this respect, the study would be somewhat analogous to that of the Astronomy Survey Committee which went beyond the Space Science Board as well as beyond NASA in its scope. Indeed the Agencies for whom the study would be of interest would include NASA, NOAA, DOD (Air Force and Navy in particular), NSF, and the USGS. The Committee feels that this study is timely, and requests that the Agency promptly initiate the study with a view toward completing it, or at least having a substantial interim report, in time for the FY 1985 budget consideration. The results of the study should be reported to both Houses of the Congress.

Annual Report for Materials Processing. The Committee is gratified that NASA, in cooperation with industry, has identified the electrophoresis process which demonstrates the real potential for the application of space technology to the needs of mankind. The Committee believes, however, that the realization of the full potential for materials processing in space would be accelerated by better program focus and direction. To encourage this, the Committee requests that NASA submit to Congress in December 1983, and every year thereafter, a comprehensive annual report on its Materials Processing in Space Program. The report should outline program objectives and direction and include research and applied science goals, milestones, status reports, budget information, and information concerning commercial, interagency and international involvement.

AERONAUTICAL RESEARCH PERSONNEL

At the core of NASA's strength in aeronautics, over many decades, have been the efforts of highly dedicated, individual researchers working with NASA test facilities. The innovations produced by people such as Dick Whitcomb at the Langley Research Center have made an immense contribution to the progress of aeronautical science.

The Committee is concerned, however, that NASA may be losing sight of the value of such in-house research. Over time, more and more of its civil service staff has been applied to administrative tasks, especially to the monitoring of contracts.

The Committee recognizes the vital importance of industry involvement in NASA aeronautical programs. Such involvement is necessary to assure that research results are translated into useful applications. Nevertheless, the Committee is concerned that too great a percentage of NASA's in-house effort is expended on administrative matters. Accordingly, the Committee requests that the Administrator examine alternatives for conducting NASA programs with a view toward increasing the number of aeronautical research personnel by 220. The Committee further requests that the Administrator report his findings by September 30, 1983.

FLIGHT RESEARCH

Aeronautical research should be among NASA's highest priorities; however, it should be remembered that not all research takes place in a laboratory. There are many who argue that flight testing is too costly and computer simulation and prediction can take the place of actually building an aircraft and flying it. This hypothesis was thoroughly refuted by former NASA Administrator James Webb. When testifying before Congress in 1967, he said:

> Flight testing of new concepts, designs, and systems is fundamental to aeronautics. Laboratory data alone, and theories based on these data, cannot give all the answers. . . . Each time a new aircraft flies, a "moment of truth" arrives for the designer as he discovers whether a group of individually satisfactory elements add together to make a satisfactory whole, or whether their unexpected interactions result in a major deficiency. Flight research plays the essential role in assuring that all the elements of an aircraft can be integrated into a satisfactory system.

The Committee supports the view that flight research is an essential phase of aeronautical R&T, and recognizing the high cost of flight testing encourages cooperative experimental flight programs between NASA and DOD. These programs should allow adequate NASA participation and involve aircraft sufficiently innovative and revolutionary to provide NASA with basic data for evaluating advanced aeronautical concepts, and ensure maximum technology transfer.

UNIVERSITY GRANTS FOR AERONAUTICAL RESEARCH

The Committee reaffirms the importance of university participation in the aeronautical research programs of NASA. Such participation is a very cost-effective means of obtaining high quality research results in a variety of fundamental discipline areas. In addition, strong university programs are needed to produce the next generation of aeronautical scientists.

Therefore, the Committee urges NASA to include in its program planning specific steps designed to assure the future vitality and productivity of university-based aeronautical research and training programs.

40 X 80 WIND TUNNEL ACCIDENT INVESTIGATION

The Committee appreciates the work NASA has done in investigating the structural failure in the 40 x 80 foot wind tunnel at the Ames Research Center, California. However, the Committee is concerned about the fact the 80 x 120 foot addition to this tunnel was managed in a way which permitted design errors to remain undetected and field changes to be made without adequate "change board" control.

The Committee deeply regrets the setback in vital research activities for 2 years and the financial loss of $12 million.

The Committee is also concerned about the division of responsibility for facilities design and construction in NASA. Such a division could lead to direction and management of large expensive projects by persons with little or no experience in construction. Accordingly, the Committee urges NASA to review and improve where appropriate the management approach and procedures for program planning and control of the design and construction of facilities at all NASA Centers. The Committee requests the Administrator to prepare a report by December 31, 1983, which describes what steps are being taken to avoid future structural facility failures. Specifically, the report should describe the organization, communication, and management tools to be used.

SPACE NUCLEAR REACTOR TECHNOLOGY

The Committee understands that space nuclear reactor technology will have both civilian and defense applications. It is also recognized that the technology base resulting from the presently existing agreement among NASA, DOE, and DARPA will provide the foundation for designing space power subsystems suitable for future, as yet unauthorized, NASA missions. It is the intent of the Committee to ensure that such mission definition analyses proceed in a deliberate and timely manner. NASA is therefore instructed to establish a mission planning and definition activity as part of the SP-100 program management plan, and to present substantive evidence to the Committee on or before October 1, 1983, that the organizational arrangements for implementing such activity are in place. The Committee anticipates that such mission studies will serve to delineate the power ranges most suited to nonmilitary uses of space nuclear reactors, and substantiate the appropriate level of authorized NASA funding for this work.

The Committee further requests that NASA provide a summary report to the Committee concurrently with the submission of the President's annual budget to the Congress for each year that details plans, accomplishments, schedules, and long range budgetary projections related to its activities in the SP-100 program.

UNIVERSITY RESEARCH INSTRUMENTATION

NASA's support to universities has declined by approximately one-third over the last decade due to other major NASA program commitments. In an environment of reduced budgets, the portion of funds dedicated to research instrumentation and equipment had declined at an even faster rate. These factors, coupled with the increasing cost of scientific equipment and the desire to maintain strong student involvement in research, have created serious problems in upgrading and replacing obsolete equipment and, therefore, have undermined the research capability and productivity of the universities that support NASA's goals and the Nation's research and development needs. The university community is a critical element of the NASA and United States long-range research capability. The augmentation recommended by the Committee will complement the recent efforts of other government agencies in attempting to reverse this deteriorating trend by providing additional funds to universities for the acquisition of modern laboratory equipment in direct support of NASA's research goals.

COMMERCIALIZATION OF REMOTE SENSING: ADOPTION OF TITLE II OF THE BILL

The Committee has consistently supported the commercial application of NASA-developed space technologies, as evidenced by its continuing struggle to maintain vigorous Technology Utilization and Technology Transfer programs. This is in part because the Committee believes that technology developed for government purposes should, where appropriate, be more widely used, and also because in many cases only the private sector with its marketing creativity can take full advantage of a new technology.

Both these reasons are operative with respect to space remote sensing. In particular the present market for Landsat data seems to be lacking some of the creativity and vigor that would be expected in a freely competitive business situation.

Thus the Committee does not question the value of private sector involvement where the strengths of this sector can be given free play by the removal of government restriction and the easy entry of competition. The question is whether or not a rapid transfer of all remote sensing systems to the private sector at this time would result in such free competition and freedom from government restraint.

Any private operation of space remote sensing systems will necessarily be somewhat restricted by government in order to ensure that the international obligations of the U.S. are observed; that the national security is not comprised; and that the public safety aspects of the weather system are maintained.

Further, if a transfer to the private sector involves a guaranteed data purchase contract with the U.S. Government, such a contract would surely inhibit other firms from entering the field, and there would be little or no competition.

It must be noted that even under the restrictive conditions described above it might still be in the best interest of the government to transfer the systems to a private sector operator, but such a decision would have to be made on the basis of careful consideration rather than on a facile assumption that any private sector operator would be more effective and efficient merely because of being in the private sector.

The Committee recognizes that the commercial market for remote sensing data is still developing, and that any private operator might need some financial assistance from the government for a period of time. This possibility is another reason why the whole issue must be looked at very carefully, and why alternatives must be considered.

One alternative approach that should be considered would involve government guarantee of data continuity for a period of years to encourage the development of a vigorous value-added industry and an associated market which eventually might justify commercialization. The value-added industry could be developed with no direct Federal subsidy (beyond the guarantee of data continuity), minimal regulation, and it would be possible for many firms to enter the business and compete.

Another alternative which the Committee does not intend to discourage is the possibility of one or more private sector entrepreneurs independently financing and launching their own land remote sensing systems. This would not limit private sector involvement to just the value-added industry. It is the intent of this Committee to encourage free enterprise and not to deter the private sector from undertaking such activities, provided they are conducted in a manner consistent with governmental policies.

The Committee also wants to be assured that there is opportunity to fully consider this issue during public hearings. Although the Committee is not opposed to commercialization in general, it must assure that the national assets represented by United States remote sensing satellite systems are used in the best national interest.

EXPLANATION OF THE BILL

TITLE I

The bill authorizes Research and Development in section 101(a), Construction of Facilities in section 101(b), and Research and Program Management in section 101(c). These activities are explained below.

RESEARCH AND DEVELOPMENT

SUMMARY

	Authorization, fiscal year 1984	Page No.
1. Space transportation capability development	$1,999,400,000	25
2. Space transportation operations	1,570,600,000	45
3. Physics and astronomy	566,600,000	51
4. Planetary exploration	220,400,000	64
5. Life sciences	59,000,000	72
6. Space applications	306,000,000	78
7. Technology utilization	10,000,000	103
8. Aeronautical research and technology	311,600,000	105
9. Space research and technology	143,000,000	130
10. Tracking and data systems	700,200,000	151
Total	5,886,800,000	

1. SPACE TRANSPORTATION CAPABILITY DEVELOPMENT, $1,999,400,000

FISCAL YEAR 1984 FUNDING LEVEL

Shuttle Production and Capability Development	$1,570,000,000
Upper Stages	143,200,000
Spacelab	119,600,000
Engineering and Technical Base	85,100,000
Payload Operations and Support Equipment	53,200,000
Advanced Programs	15,000,000
Tethered Satellite System	3,300,000
Total	1,999,400,000

The Space Shuttle is the key element of a versatile Space Transportation System (STS) that is available to a wide variety of national and international users. The Space Shuttle is the first reusable space vehicle and is configured to carry many different types of space applications, scientific, and national security payloads. The Space Shuttle offers unique capabilities that cannot be achieved with today's expendable launch vehicles—to retrieve payloads from orbit for reuse; to service and repair satellites in space; to transport to orbit, operate, and return space laboratories; to transport materials and equipment to orbit; and to perform rescue missions.

Shuttle production and capability development provides for the national fleet of Space Shuttle orbiters, including main engines, and provides for the launch site and mission operations control requirements, initial spares, production tooling, and related supporting activities to meet appropriate national needs. More specifically, this line item contains the orbiter production contract for the second, third, and fourth flight orbiters, the changeover of the first oribter into its operational configuration, and the provisions for procurement of spare orbiter structural components; the continuing capability development tasks for the orbiter, main engine, external tank (ET) and solid rocket booster (SRB); the provision of the second line of processing stations and equipment for launch and landing; the development of the filament wound case (FWC) solid rocket booster; the lay-in of spares and the ground support equipment; and the production rate tooling for the ET and SRB. Equipment modifications to two orbiters, mobile launchers, and launch pads for the 1986 launches of the Centaur as a Space Transportation System upper stage are also funded under this budget item. The second phase of development of the Mission Control Center (MCC Level II), operations effectiveness studies, and changes and systems upgrading are also provided for under Shuttle production and capability development.

The upper stages program includes the effort necessary to provide upper stages for use with the Space Shuttle to place payloads in orbits and trajectories beyond the capability of the Shuttle alone, primarily for planetary and geosynchronous missions. Current developments include the two-stage configuration of the Inertial Upper Stage (IUS), and the modification of the Centaur for use in the Shuttle.

The engineering and technical base provides the core capability for the engineering, scientific, and technical support required at the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the National Space Technology Laboratories (NSTL) for Space Transportation Systems research and development activities.

The Spacelab is a major element of the STS and provides a versatile, reusable laboratory which will be flown to and from Earth orbit in the Shuttle orbiter cargo bay. The program is being carried out jointly by NASA and the European Space Agency (ESA). NASA's support of the Spacelab development effort includes hardware and system activation efforts which assure Spacelab compatibility with the orbiter, leading to an operational capability.

Payload operations and support equipment provides for developing and placing into operational status the ground and flight systems necessary to support the NASA payloads during pre-launch processing, on-orbit mission operations, and, when approporiate, post-landing processing.

The advanced programs effort identifies potential future space programs and provides technical as well as programmatic data for their definition and evaluation. In support of this effort, advanced development activities are conducted to provide a basis for obtaining significant performance and reliability improvements and reducing future program risks and development costs through the effective use of new technology. Key elements of this activity are the numerous system trade studies related to space stations.

The Tethered Satellite System (TSS) will provide a new capability for conducting space experiments at distances up to 100 kilometers from the Shuttle orbiter while being held in a fixed position relative to the orbiter. This program will be undertaken in conjunction with the Italian government.

The orbiter production activities provide for the completion of fabrication and delivery of the four-orbiter fleet. Columbia (OV-102) was used to fly the four orbital flight tests and first operational mission; Challenger (OV-099) is at KSC preparing for its first mission (STS-6); and, Discovery (OV-103) and Atlantis (OV-104) are scheduled for delivery in September 1983 and December 1984, respectively. Progress on OV-103 and OV-104 to date indicates that the planned delivery dates can be achieved. Modifications to enable the launch of the Centaur upper stage on OV-099 and OV-104 are underway; the modification kits will be installed in FY 1986. The Columbia (OV-102) is now undergoing a period of modification at KSC in order to prepare the vehicle for the launch of the first Spacelab mission, currently planned for September 1983. The Columbia will be modified to full operational configuration in FY 1985, although these modifications may be rescheduled for an earlier date pending an evaluation of the training and vehicle processing requirements associated with maintaining orbiters having two different configurations. Oribter spares procurements to establish the required level of spares availability at the KSC launch site are continuing, and close attention is being given to the estimated spares requirements as a function of the experience being gained during operations. The Administration has authorized the inclusion in this budget request of the amounts required to procure extensive spares to ensure the operational viability of four-oribter fleet; initiation of procurement is planned for FY 1983.

At KSC the second line of vehicle processing stations is being phased in to support launch processing of two of more orbiters simultaneously. The second mobile launcher platform was brought on-line in August 1982 and the second bay of the orbiter processing facility became operational in June 1982. The second set of high bays in the vehicle assembly building (VAB) will be ready for operations in the summer of 1983, the launch processing system's software production capability and second firing room will be ready in the fall of 1983, and the SRB processing and storage facility will be available in early 1984. The second launch pad (Pad B) is now planned to be operational in January 1986, consistent with the requirements to support the launches of the Galileo and International Solar Polar Mission (ISPM) in May–June 1986. The third mobile launcher platform, on which design work was initiated in 1982, is planned for a September 1986 readiness date. Modifications to the mobile launcher platforms (MLP-1 and MLP-2) and to launch pad systems to be compatible with the use of the Centaur as a Shuttle upper stage were authorized in 1982 and the design work is underway.

Development testing and production continue on the Space Shuttle main engine (SSME) in its full power level (FPL) configuration. Production engine delivery schedules have been adjusted to permit the changeout of the Columbia's rate power level engines after the fifth flight (instead of the ninth flight) and for the addition of an engine (2027) to the production sequence to replace engine 2013, destroyed in an early FPL certification test. Engine test incidents in 1982 indicated the need for additional hardware fabrication to support the on-going FPL test schedules. Replacement of the hardware lost during the past year and provisions for long-lead hardware to support the ground test program are reflected in the current estimates for FY 1983 and in the FY 1984 request. On the positive side, however, the performance of the main engines in their first five flights has validated the concept of a reusable rocket engine having high thrust capability.

The ET performance on its first five flights was excellent. The delivery of the new lighweight tank was made on schedule and with greater weight savings than initially planned. The first flight of the lighweight tank is planned for STS-6. Emphasis continues on the cost-reduction/producibility and production readiness. Efforts continue to identify and implement the associated flow and processing improvements needed to meet cost and production objectives. Rate tooling for the ET is based on supporting a flight rate of 24 per year, although the planning is based on maintaining a capability to increase production above that rate. Effort continues to identify "choke points" where additional tools or cells will be required at the Michoud Assembly Facility to meet the current capability requirement. Preliminary reviews indicate that additional tools and equipment will be necessary in a number of manufacturing areas; the preliminary findings will be defined in detail along with the implementation schedule and funding requirements. Based on fabrication and flight experience, there is a reduction in the amount of super lightweight ablator (SLA) required on the tank, and a number of SLA application tools have been eliminated.

The experience with the SRB's during the initial flights has revealed the need for design improvements to reduce the amount of water impact damage to the SRB's aft end, particularly to the hydraulic power units mounted internally to the aft skirt. Interim fixes have been pursued, resulting in reduced damage to the SRB's on STS-5. Work is underway on new designs to provide a long-term solution.

The development of the filament wound case (FWC) for the SRB has been initiated to improve the performance of the Space Shuttle for high performance missions. The filament wound case contractor has been selected. The expected weight reduction in the SRB by using the FWC in place of the steel cases is estimated at 66,000 pounds, resulting in a payload capability improvement of approximately 5,500 pounds. Integration analyses were started in 1982 to determine the loads effect on the orbiter and the ET and to analyze the lift-off loads induced by the launch platform at the Vandenberg launch site.

Emphasis during 1983 and 1984 will be concentrated on SRB refurbishment tooling and facilities in order to meet a flight rate of 24 sets per year.

In upper stages, a joint development program with the DOD, has been initiated for the use of the Centaur as a STS upper stage. The Centaur/STS will be a wide-body derivative of the Centaur stage used in the Atlas-Centaur program. The common vehicle, designed Centaur-G, will accommodate a 40-foot long, approximately 10,000-pound payload in the bay of the orbiter, and be capable of placing it into geosynchronous orbit. A longer version of the Centaur-G, known as G-prime, is being developed by NASA for planetary missions. The Air Force and NASA will equally share common design and development costs for the Centaur-G. An agreement on the Centaur was signed by the Air Force and NASA in November 1982. The Centaur-G-prime will be first used for launching the Galileo and ISPM spacecraft in 1986, replacing the previously planned planetary version of the Inertial Upper Stage (IUS).

Another adjustment to the IUS production program will result in a reduction in the number of vehicles delivered to NASA for the launch of the Tracking and Data Relay Satellites (TDRSS). As a result of the restructuring of the Tracking and Data Relay Satellite System (TDRSS) service agreement to make the TDRSS a dedicated Government system, the near-term requirement for IUS vehicles to support the TDRSS launches has been reduced from six vehicles to four. The Air Force is planning to complete the two vehicles no longer required by NASA and to assign them to DOD missions. The initial launch of the TDRS/IUS on the Shuttle is planned on STS-6. Two additional spacecraft will be launched to complete the TDRSS in-orbit constellation. A ground spare spacecraft and IUS vehicle will be maintained to provide the capability to replace an orbital spacecraft in the event of a spacecraft failure.

The initial Spacelab flight units (module, pallets, and igloo) and ground support equipment were delivered by the ESA in 1982. The first crew transfer tunnel, a U.S. development responsibility, was delivered to KSC in December 1982. Fabrication of the verification flight instrumentation for the initial Spacelab mission has now been completed, and integration of the software for the Spacelab simulator being used in training for this mission was also completed. Preparations for the flight of Spacelab-1 in September 1983 are well underway.

In advanced programs, mission analysis studies are in process for a possible future space station. A space station task force has been formed within NASA to review the merits and technical feasibility of establishing a permanent manned presence in space. Contractor mission analyses were initiated in 1982, and preliminary reports have been made by the contractor teams; final reports will be completed in mid-1983. In other advanced programs areas, the advanced development of the Tethered Satellite System will continue, leading to the proposed initiation of hardware development in FY 1984. Preliminary definition of advanced transportation vehicle concepts, including orbital transfer vehicles, teleoperator maneuvering vehicles, and Shuttle-derived launch vehicles, is also being conducted. Work is proceeding on the investigation of advanced systems, tools, and techniques for placement, retrieval, and maintenance/repair of spacecraft.

In payload operations and support equipment, payload integration support and payload-related hardware are developed and furnished for NASA payloads. A key activity currently underway is the support of the retrieval/repair mission for the Solar Maximum Mission spacecraft, which is being undertaken with funding supplied by both NASA and the DOD. This mission is currently planned for mid-1984. Multi-mission payload equipment being developed includes a payload bay bridge structure to carry small payload, apparatus for providing cooling of the heat generated in the orbiter bay by the radioisotope thermal generators (RTG's) used for planetary missions, and a standard mission cable wire harness for mixed cargoes. The Payload Operations Control Center (POCC) at JSC is presently being readied to support the operations of the Spacelab-1 mission in September 1983.

SHUTTLE PRODUCTION AND CAPABILITY DEVELOPMENT

FISCAL YEAR 1984 FUNDING LEVEL

Orbiter	$794,600,000
Launch and mission support	245,500,000
Propulsion systems	477,200,000
Changes and systems upgrading	52,700,000
Total	1,570,000,000

The objectives of this program are to provide for: the completion of the national fleet of Shuttle orbiters; the production and capability development of the propulsion systems; the mission preparation, mission control, and launch site capabilities; and the potential changes and upgrading to the Space Transportation Systems.

The planned four-orbiter fleet includes: Columbia (OV-192), the orbiter vehicle developed under the Space Shuttle design, development, test and evaluation (DDT&E) program and used for the first five flights; Challenger (OV-099), the second flight orbiter, which was fabricated using elements of the DDT&E structural test article; and two orbiters—Discovery (OV-103) and Atlantis (OV-104)—which are in production now and are of a lighter-weight configuration. The planned delivery dates for the two vehicles in production are September 1983 for OV-103 and December 1984 for OV-104. OV-102 is undergoing modifications at KSC in order to prepare the vehicle for the launch of the first Spacelab mission in September 1983. The final phase of modifications for OV-102 is now planned for FY 1985; these modifications may be rescheduled for an earlier date. OV-099 was delivered to KSC on schedule in July 1982, and is undergoing final checkout prior to its first launch in early 1983. Work was initiated in FY 1982 on the modifications to the orbiter and the related systems integration analyses for the use of the Centaur as a Shuttle upper stage. Two orbiters—OV-099 and OV-104—will be modified to carry the Centaur and its payloads. The provisioning of orbiter spares is an on-going activity to support the requirements for the initial lay-in of line replaceable units of equipment at the launch sit. In addition, the budget provides for the extensive acquisition of orbiter structural spares to support the four-orbiter fleet and provides funding to maintain production readiness for a fifth orbiter.

Launch and mission support provides for augmentations to the first line of processing stations at the KSC; the additional astronaut training, mission preparation and mission operation capabilities required for higher flight rates; the modifications to the launch site capabilities to accommodate the new Centaur upper stage; and, studies and analyses of program level improvements for the operations and management of the STS. The first line of KSC facilities (funded under Space Shuttle DDT&E) supported the launch processing and checkout of one orbiter vehicle from landing through launch. The second line of processing stations will support launch processing and checkout of two or more orbiters simultaneously, and will allow the east coast launch traffic to increase to 17 flights in FY 1987. A third Shuttle training aircraft will be acquired to support increased training requirements and permit the existing two aircraft to be overhauled when fatigue considerations make this necessary. The upgrading of the Mission Control Center (MCC) provide for reconfiguration of the JSC Mission Control Center to support two, and finally three, simultaneous orbiter operations (flights, tests, or simulations).

Propulsion systems provide for the continued production and ground testing of the Space Shuttle main engines, for production rate tooling and equipment for the SRBs and ETs, for systems support to the main propulsion tests of the main engines, and for the development of the filament wound composite motor case for the SRB. Funding for the FWC and related integration analyses (such as liftoff and initial flight phase structural loads analyses) is included in Shuttle production and capability development at $7.0 million in FY 1982, $55.0 million in FY 1983, and $80.1 million in FY 1984. In addition, the propulsion systems area continues to fund the design and development of improvements to the SRB to minimize flight and water impact damage, and for producibility and production readiness activities supporting fabrication.

Changes and systems upgrading provides funding for potential changes and system modifications as well as unanticipated new requirements not covered in the budget estimates for the above activities and other program elements. Examples of the use of such provisions recently include the initiation of work on the third mobile launcher platform in FY 1982 and FY 1983, for the third Shuttle training aircraft in FY 1983, and for the procurement of additional main engine hardware to replace hardware damaged or destroyed in ground engine testing.

Orbiter

The objective of this program is to continue the orbiter production activities for OV-103 and OV-104 and related supporting efforts to meet the needs of NASA, the DOD, and other domestic and international users. The reusable orbiter is a key element in the STS, providing reliable, efficient and econonical access to space. OV-099 was delivered on schedule to KSC in July 1982, and is now undergoing final checkout prior to its first launch in early 1983. With this delivery, there are now two vehicles in flow at

KSC. OV-102 completed its fifth flight in November 1982, which marked the beginning of operational activities as it placed two commercial satellites into orbit.

Columbia (OV-102) is now undergoing a period of modification at KSC in order to prepare the vehicle for the launch of the first Spacelab mission in the fall of 1983. The final phase of modifications for OV-102 currently planned for FY 1985 will bring this orbiter into a fully operational configuration. However, as the problems of operating two orbiters in different configurations become better understood, it may be necessary to move these final modifications forward to FY 1984.

The Shuttle production program is progressing toward the planned delivery of the third orbiter, OV-103 in September 1983. Major elements of OV-103 have been delivered to Palmdale for final assembly. These include the mid fuselage, elevons, wings, vertical tail, and lower forward fuselage. Through January 1983, over 10,000 tiles will have been installed. The OV-103 effort is progressing satisfactorily and the current status of manufacturing and checkout is consistent with the planned September 1983 delivery. The delivery date for OV-104 remains December 1984. Subcontractor deliveries on OV-104 are already occurring and will be 80 percent complete at the end of FY 1983. Maintenance of the OV-103 and the OV-104 delivery dates is consistent with the orbiter allocation plans for meeting the initial operational capability date for the Vandenberg Air Force Base launch site in October 1985.

The modifications to the orbiter for carrying the Centaur as an upper stage are currently in the design phase. Orbiter ground support equipment and modification kit designs will undergo a preliminary design review in early 1983 and a Critical Design Review in late 1983. Procurement of the necessary propellant servicing quick disconnects has been initiated. Modification kits for the two orbiters should be completed by early 1985.

Systems integration activities being conducted include the assessment of the lift-off and initial flight phase structural loads for new system elements, particularly for the impact of the filament wound case for launches from Vandenburg; the flight-by-flight performance margin assessments; post-flight performance and anomaly analysis and reconstruction; turnaround reduction analyses; contingency abort analyses; and Vandenburg systems integration. The analyses of the system level verification and integrated testing requirements for the Centaur upper stage represent a major activity within systems integration to assure that the Centaur can be safely and effectively integrated into the STS.

The procurement and fabrication of orbiter spares continues. Maintenance requirements analyses for line replaceable units are underway at the prime contractor's plant and at subcontractor facilities. These analyses are based on test and flight experience, and form the basis for deciding the timing of the spares procurements. These spares cover not only avionics units (such as flight computers), but also mechanisms (e.g., payload door latches, actuators, and power drive units) and propulsion systems (reaction control system engines and orbit maneuvering system engines).

Procurement of additional structural assemblies and components for the orbiter has been authorized by the Administration to ensure the long term operational viability of the four-orbiter fleet by providing the capability to repair or replace structural components in the event of damage to those components. Procurement of these assemblies will be initiated in FY 1983 after the receipt of the prime contractor's proposal and NASA's review and approval. This action will also reduce the lead time for expansion or replacement of the four-orbiter fleet when operational demands of the Space Transportation System so require. Major structural assemblies and selected structural parts are planned to be fabricated. Structural parts include the rudder, elevons, speed brake, landing gear, and landing gear doors. Major structural assemblies include the wings, aft thrust structure engine compartment, crew module (including the nose and cockpit), mid and aft fuselage sections, payload bay doors, vertical tail and the orbital maneuvering system pods. All of the major structural assemblies will be completed up to the point where they would be ready for installation of the thermal protection system, plumbing, wire harnesses, and major electrical, propulsion, and hydraulic components.

A major effort in FY 1984 will be the completion of the final stages of manufacturing on OV-104 at the Rockwell Palmdale facility, including final assembly and integrated testing, leading to its delivery in December 1984. FY 1984 funding is also being requested to provide for procurement of major structural components as spares for the orbiter fleet. These structural components will include elements such as wings, vertical stabilizer, crew module, payload bay doors, and aft thrust structure. These items will be assembled into varying stages of completion so that they can be used as structural spares for the current fleet. FY 1984 funding will also be utilized for performance augmentation activities primarily to conduct orbiter loads analyses in support of the filament wound case (FWC) development program, and for modification of OV-099 and OV-104 to accept, boost, and deploy the wide-bodied Centaur upper stage. Ground support equipment and test hardware are also provided to support KSC activities.

In FY 1984, systems integration activities will be concentrated on the engineering analysis and integration support for vehicle capability changes as the Space Shuttle performance improvements (such as the filament wound case) are brought into the program; support to STS cargo operations and the flight program, including the investigation/resolution of flight problems; and support of the Vandenberg launch site activation.

Logistics support to the Space Shuttle program requires the lay-in of orbiter and main engine spares and ground support equipment needed for replacement of Shuttle components and for support to ground processing operations as the fleet size and flight rate increase. Projected failure rates for each item, and turnaround times for repairs are two significant factors in determining the quantity of spares to be procured. The funding for orbiter spares covers not only the cost of orbiter flight spares and ground support equipment spares, but also the logistics support to analyze requirements and procure these spares.

Launch and Mission Support

The first line of stations previously activated at KSC supports the launch processing and checkout of one orbiter vehicle from landing through launch. The second line of stations is being phased in to support launch processing of two or more orbiters simultaneously. The second high bay of the orbiter processing facility and the second mobile launcher platform (MLP) became operational in June 1982 and August 1982, respectively, to provide parallel processing of OV–099 and OV–102 through the first portion of two processing lines. Other stations to be activated in the "second line" include a second set of high bays in the VAB, a second launch pad, a SRB processing facility, a ground software production capability, a second operational firing room, and a third MLP. The changes to the launch pads, MLPs, and supporting elements to enable the use of the Centaur upper stage have been initiated. The second launch pad activation schedule has been accelerated from September 1986 to January 1986 in accordance with the station need dates to support the two planetary launches in 1986.

Also under launch and mission support are the procurement and modification of a third Gulfstream II for use as a Shuttle training aircraft, the fabrication of the manned maneuvering units and extra-vehicular mobility units (space suits), and other mission support activities for training and simulations. These activies include the operations of the Shuttle engineering simulation system, the modifications to the Shuttle mision simulator, the operations of the data reducation center, procurement of TACAN ground stations, changes to systems supporting the Shuttle mission simulator to provide more rapid mission-to-mission reconfigurations of the training software, and support of post-OFT development tests objectives. The two manned maneuvering unit flight articles are scheduled for delivery in January and July of 1983. It has been decided to limit the extra-vehicular mobility unit procurement quantities by reducing the number of sizes to provide for medium and large sizes only. The Shuttle training aircraft has been identified by the JSC personnel responsible for crew training as being of great importance in assuring crew familiarity with the orbiter's handling characteristics prior to landing; a third shuttle training aircraft is required to meet crew training requirements in light of the eventual need for overhaul of the present two aircraft when fatigue considerations prompt this change.

Within launch and mission support are the operations effectiveness effort and the Mission Control Center upgrading (Level II). Operations effectiveness is a program evaluation activity intended to identify those program level improvements in operating and managing the STS which would improve the overall effectiveness of the system.

The Mission Control Center upgrading (Level II) will provide for the reconfiguration of the MCC at JSC to support the STS's operation flight schedule requirements. The use of additional hardware, equipment, and software to operate the MCC will provide for systems monitoring and flight control capability in support of two, and later three, simultaneous operations (flight, test or simulation). Funds are required to complete the flight control room on the second floor of the MCC and initiate capability development for three vehicle operations. The major milestone for the higher flight rate capability is two-vehicle capability in April 1984.

Several major activites will be underway during FY 1983, including the final installation and activation of VAB high bay cells ½ and the launch processing software development system to meet the FY 1983 operational readiness dates. This work phases into the facilities (funded under Construction of Facilities appropriation) being completed, including the retrieved SRB safing, repainting and refurbishment work stations, and new SRB processing and storage facilities during the first half of FY 1984. There are also modifications to improve the capability of the spacecraft assembly and encapsulation facility (SAEF–2) by December 1984, and to construct and activate a cargo hazardous servicing facility by October 1985. Procurement, installation, and checkout of equipment funded are under this budget element in FY 1984 to support the above described facilities funded from the Construction of Facilities appropriation. Larger second line station projects starting in FY 1983 and continuing through FY 1984 include the construction, outfitting, and activation of launch pad B and MLP–3, and the Centaur-related modifications of launch pads A and B to add a rolling-beam type liquid-hydrogen loading umbilical system on each launch pad. Another Centaur-related change is the addition of another liquid oxygen loading umbilical on each MLP. These new systems plus a set of current-design umbilicals and swing arms for pad B are to be tested and proofed at the launch equipment test facility.

Also under launch and mission support are the procurement and modification of a third Gulfstream II for use as a shuttle training aircraft, the fabrication of the manned maneuvering units and extra-vehicular mobility units (space suits), and other mission support activities for training and simulations.

Propulsion Systems

Propulsion systems provides for the production of the Space Shuttle's main engines and the development of the capability to support operational requirements established for the main engine, SRB, and ET. In the main engine program, production and capability development covers the production of the main engines required for the orbiter fleet, the procurement of spares, ground testing operations, and anomaly resolution capability.

The main engines performed superbly during the first five flights of the Space Shuttle, culminating many years of testing and continuing engineering analyses. The fact that these flights were completed with no significant in-flight anomalies and with only minimal between-flight maintenance validated the concept of the reusable high-performance rocket engine. The main engine program is currently focused on the flight certification testing of the new full power level engines. This engine will produce 512,000 pounds of thrust in vacuum, i.e., 109 percent of the thrust produced by the engines used on Columbia for its first five flights. As of December 1982, this new configuration engine has completed more than 170 tests totaling over 45,000 seconds of test time, and has successfully completed three of the planned four flight certification cycles. Full certification is planned to be completed by February 1983. Production engine delivery schedules have been adjusted to compensate for the changeout of the Columbia's engines after the fifth flight and for the addition of an engine (2027) to the production sequence to replace engine 2013, destroyed during early full power lever certification testing. Engine test incidents during FY 1982 also led to the need for additional hardware fabrication to support the ongoing test program.

Although the SRBs performed well during the initial five flights, the damage incurred upon water impact—as well as the loss of the STS-4 boosters due to problems experienced with parachute deployment—has resulted in the need for design improvements to reduce the amount of damage, particularly to the aft skirt equipment. Interim fixes have been pursued, resulting in reduced SRB damage on STS-5. The loss of the SRB's on STS-4 has been traced to a premature separation of the main parachutes from the booster at frustrum separation. Design improvements are being studied to reduce the damage experienced to the thrust vector control system. The aft skirt structures are being strengthened as well. The new high performance motor, scheduled for flight in 1983, successfully completed its developmental test firing in October 1982; the qualification motor test firing is scheduled for March 1983 and first flight use is planned on STS-8 in mid-1983.

The SRB program includes the development of a filament wound composite motor case. This development effort will enable the replacement of the current steel case segments for high performance launches. The performance increase is achieved by a reduction in the Shuttle liftoff weight of approximately 66,000 pounds as compared to the baseline steel case motors. This results in a payload capability improvement of approximately 5,5000 pounds. The development contractor has been selected and work has been initiated. Structural development tests will be conducted in 1983 at the subscale, quarter scale, and full diameter configuration levels. The first flight use is planned for late 1985 on the initial Vandenberg launch.

In the SRB, efforts will continue on the improvements to the thrust vector control system and other program elements to minimize flight damage and improve turnaround times on reusable hardware. Procurement of manufacturing tools, transportation support equipment, and related items will continue in support of reaching a 24 per year flight rate objective. In the filament wound case development activity, funding in FY 1984 provides for completion of characterization tests of the specific composite selected for use; reusability/refurbishment studies; subscale and full scale burst tests; motor firings of the first and second full scale development articles; and, initial fabrication of the first flight article.

In the ET program, significant progress has been made on the development of the new lightweight tank, including the changes to the manufacturing tools at the Michoud Assembly Facility involved in changing over from the heavyweight to the lightweight configuration. The first lightweight tank was delivered on schedule to the KSC in September 1982. A key element of the program has been to identify manufacturing flow "choke points" where existing tools require modification or new tools should be added to meet the production capability requirement of producing 24 tanks per year by

1987. Emphasis continues on efforts to reduce manufacturing costs and improve the production capability of the systems supporting the manufacturing operations.

In the ET program, producibility and production readiness activities will continue to support cost reduction and manufacturing processes improvement objectives. The manufacturing tools and equipment to support the 24 per year production rate build-up will be the principal focus of the FY 1984 program. Major tools, including tools for welding, machining, X-ray and for the application of insulation, as well as handling fixtures and transportation equipment are being procured.

In systems support, preparations are underway for the test of the full power level engines in the main propulsion test article stand at the NSTL in April 1983. This test will provide for a check of the main engines' performance in conjunction with the main propulsion system hardware mounted in the aft end of the simulated orbiter.

In FY 1984, funding for the main engine provides for those activities necessary to support the orbiter production, flight schedules, and ground testing. Production flows have been adjusted to compensate for the planned changeout of the Columbia engines after five flights (instead of nine) as well as the addition of an engine (2027) to the production sequence as previously addressed. Flight spares lay-in, anomaly resolution testing, and continued certification and development testing are also provided for within the main engine budget estimates.

Changes and Systems Upgrading

Management, technical flight experience, and cost reviews of the Space Shuttle program have stressed the need for providing an adequate allowance for changes and modifications which inevitably are required in a large, complex, and technically demanding space system.

The changes and systems upgrading budget represents the estimated requirement for potential changes and systems modifications and unanticipated developments which are not included in the program element budget estimates. Such funds are necessary to provide for programmatic and technical changes, such as modifications to the orbiters to improve flight performance and system reliability, changes and upgrading of ground systems to reduce turnaround time between missions, and replacement/modification of hardware elements to achieve increased operating economics.

As the changes and upgrading requirements are identified and approved, funds are allocated to the appropriate budget account.

The funding requested for FY 1984 will provide for those changes which are considered to have the highest priority. The objectives are to improve reliability, increase efficiency, and reduce costs. Changes and upgrading areas of interest include modifications to flight and ground systems; design and development of hardware/software systems which meet requirements for improved safety, reliability, performance and cost-effectiveness; and changes which will reduce operational costs by extending operational life, by facilitating improved mission-to-mission turnaround time, and by improving mission performance margins.

UPPER STAGES

FISCAL YEAR 1984 FUNDING LEVEL

Development	$80,900,000
Procurement and operations	62,300,000
Total	143,200,000

The STS upper stages are required to carry Shuttle-launched payloads to orbits not attainable by the Shuttle alone. The Inertial Upper Stage (IUS), the Centaur, and the Payload Assist Modules (also called Spinning Solid Upper Stages) represent the three classes of upper stages available for use with the STS.

The IUS is being developed under a DOD contract to provide the capability to place payloads of up to 5,000 pounds into geosynchronous orbit. The first IUS launch took place in October 1982 in conjunction with a Titan 34-D booster; this combination successfully delivered two DOD communication satellites to the desired orbit. Inertial Upper Stage launch operations are proceeding on schedule for the first IUS/STS launch in early 1983 carrying the TDRS-A spacecraft. Plans for development of a planetary version of the IUS have been terminated. The number of IUS vehicles being procured for launches of the Tracking and Data Relay Satellite System has also been reduced, consistent with the change of the TDRSS to a dedicated Government system.

NASA and DOD have entered into a joint development program for a wide-body derivative of the Centaur stage as used in the Atlas Centaur program. The common vehicle, designated Centaur-G, will accommodate a 40-foot long, approximately 10,000-pound payload in the orbiter vehicle bay, and be capable of placing it into geosynchronous orbit. A longer version of the Centaur-G, known as G Prime, is being developed for launch of the Galileo and ISPM spacecraft in mid 1986. Two Centaur-G Prime vehicles are currently under procurement for the Galileo and ISPM missions. The Air Force and NASA will equally share common design and development costs for the Centaur-G. The Air Force and NASA will separately budget for hardware production and operations costs associated with each agency's missions. Both NASA and DOD plan additional procurement of vehicles at a later date to meet future requirements. NASA plans to start procurement in FY 1985 of a Centaur-G vehicle to support the 1988 launch of the Venus Radar Mapper (VRM) mission. The planned activities for Centaur in 1983 include the work required on the RL-10 engine used in the Centaur stage, including selected advanced development activities to investigate low thrust operations and extendable nozzle exit cones.

The objective of the Payload Assist Module (PAM) program is to provide low cost transportation, of principally commercial spacecraft, from the Shuttle's low Earth orbit to geosynchronous transfer orbit. The Delta class PAM-D is capable of injecting up to 2,750-pound payloads into geosynchronous transfer orbit. The Atlas-Centaur class (PAM-A) will be capable of inserting 4,400-pound payloads into the same orbit. PAM's are being developed commercially, but NASA monitors the development and production to assure that the PAM is technically adequate and will be available when needed. Eight PAM-D's have been successfully launched atop the Delta expendable launch vehicle and two more were successfully flown on STS-5. The PAM-D II is being developed commercially and will be capable of injecting 3,500 pound payloads into geosynchronous transfer orbit for mission to be launched beginning in early to mid 1985.

Funds are required to complete the procurement of NASA's four IUS vehicles and to support the checkout and launch of the third Tracking and Data Relay Satellite (TDRS-C).

The FY 1984 funds are required to continue the development of Centaur-G and G-Prime and the procurement of two Centaur G-Prime vehicles to support the Galileo and ISPM launches in 1986. The development effort in FY 1984 provides for the NASA share of the funding for the development of the common Centaur-G vehicle and the NASA costs for the additional development of the Centaur G-Prime. This includes the preliminary design review for all G-Prime subsystems, the Critical Design Review for the G-Prime Centaur integrated support structure and adapter, and the Critical Design Review for the test tanks and adapters for the G-Prime test vehicle. The procurement and operations resources are required to obtain long-lead materials for the G-Prime vehicles for the Galileo and ISPM missions, to conduct the Preliminary Design Review for the flight vehicles, and to initiate manufacturing of the G-Prime flight hardware. Also, procurement of the PAM-A upper stage will be continued.

SPACELAB

FISCAL YEAR 1984 FUNDING

Development	$100,200,000
Operations	19,400,000
Total	119,600,000

The Spacelab is a versatile, reusable facility carried in the cargo bay of the Space Shuttle orbiter which affords scientists the opportunity to conduct scientific experiments in the unique environment of space. Ten European nations, including nine members of the European Space Agency (ESA), are participating in this joint development program with NASA. ESA has designed, developed, produced, and delivered the first Spacelab consisting of a pressurized module and unpressurized pallet segments, command and data management, environmental control, power distribution systems and much of the ground support equipment and software for both flight and ground operations. The Instrument Pointing System is scheduled to be delivered in FY 1984.

NASA is responsible for the remaining hardware including such major elements as the crew transfer tunnel, verification flight instrumentation, certain ground support equipment, and a training simulator. Support software and procedures development, testing, and training activities not provided by ESA which are required to demonstrate the operational capability of Spacelab are also included in NASA's funding. NASA is procuring an additional Spacelab unit from ESA under terms of the ESA/NASA Memorandum of Understanding and the Intergovernment Agreement.

Spacelab operations provide for mission planning and flight and ground operations for all missions other than the development flights (SL-1 and SL-2). This includes integration of the flight hardware and software, payload operations data management, and logistical support.

During FY 1982, ESA Spacelab engineering model pallets were used to carry the science and applications experiments conducted on STS-2 and STS-3. The second flight configuration model of the Spacelab, which will be flown on SL-2, and the second set of ground support equipment were delivered by ESA to NASA in FY 1982. With the exception of the Instrument Pointing System, these are the last major elements of the ESA Spacelab development to be delivered to the United States. With these deliveries, there has been an increase in Spacelab activities at the KSC, involving the receipt, assembly, installation, checkout, and processing of the Spacelab hardware.

In December 1982, the first crew transfer tunnel was delivered to KSC. This tunnel will link the Spacelab module to the Shuttle orbiter cabin for the first Spacelab flight (SL-1). Fabrication of the verification flight instrumentation for the SL-1 mission has now been completed. The utility kits, which serve as Spacelab-to-Shuttle orbiter mating hardware, have also been delivered. Integration of the software for the Spacelab simulator, which will be first used in training for SL-1, was completed early in FY 1983. Ground support equipment and facility verification testing was completed and Spacelab launch processing is well underway. KSC is engaged in integrating the experiments into the Spacelab flight module and onto the pallet that is scheduled to be flown in the cargo bay of the Shuttle in September 1983. This work is being performed by the Spacelab integration contractor for NASA.

Four pallets and six racks were delivered to NASA early in FY 1983. These deliveries are from the follow-on procurement contract which NASA signed with ESA in FY 1980 to purchase the second Spacelab. This contract represents a major portion of the FY 1983 and FY 1984 funding for Spacelab development. The hardware fabrication is well along and major deliveries will take place in FY 1984.

The first Spacelab verification flight (SL-1) is currently scheduled for the end of FY 1983. FY 1984 funding is required to check out the Spacelab system components after flight and conduct post-flight data analysis for that mission. The second verification flight (SL-2), scheduled for FY 1985, will require funding for analytical and physical integration, for checkout of the Spacelab elements, and to support training, including the operation of the Spacelab simulator. Development of the NASA-furnished ground support equipment required for SL-2 is planned to be completed in FY 1984.

Modification of ESA flight hardware and procurement of spares for both NASA-developed hardware and for hardware developed by U.S. companies under contract with ESA will continue in FY 1984. Funds are also required for expansion of the Software Development Facility's capabilities to support the planned flight rate. Production of the second Spacelab flight unit, which is under contract with ESA, will continue with major components scheduled to be delivered in FY 1984. Funding is also required for the initial lay-in of spares for the ESA-delivered hardware and to provide the sustaining engineering for all hardware and software beyond that for which ESA is committed.

FY 1984 operations funding is required for processing OSTA-3, SL-3, and the special structure missions (LFC-1, MEA-1, OAST-1 and OSTA-4). Staging and integration activities for OSTA-3 will lead to a launch planned for the last quarter of FY 1984. Integration and checkout of the Spacelab elements for the SL-3 mission are scheduled to completed and ready for launch in the last half of FY 1984. Analytical integration, configuration management, and software development are additional activities to be conducted in FY 1984.

ENGINEERING AND TECHNICAL BASE

FISCAL YEAR 1984 FUNDING LEVEL

Research and test support	$40,100,000
Data systems and flight support	13,100,000
Operations support	37,000,000
Launch systems support	2,900,000
General reduction	*8,000,000*
Total	85,100,000

Through FY 1982, certain specific STS program support functions at the NASA field centers were funded in the Development, Test and Mission Support (DTMS) program element. The Engineering and Technical Base (ETB) represents a change in the approach to funding these functions. The ETB will provide only the core capability required to sustain an engineering and development base for various STS programs. Additional center program support requirements above the core level are consequently funded within Shuttle operations and Shuttle production and capability development. The centers involed are the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the National Space Technology Laboratories (NSTL).

The core level of support varies from center to center due to programmatic and institutional differences. At JSC, the core level requirement is that one shift of operations be maintained in the engineering and development laboratories, White Sands Test Facility, and reliability and quality assurance areas. The core level for the Central Computer Complex is established as a two-shift operation. The funding for center operations base support is split between the ETB and Shuttle operations budget elements in accordance with the principle that ETB will provide the core level and the benefitting program is responsible for funding additional support requirements. At KSC, due to its operational character, the core level provides only for the analysis of improvements to KSC operations. The shift to the ETB concept did not result in significant changes to the funding for MSFC and NSTL operations. These centers will continue under ETB to use these funds at MSFC for multi-program support activities, including computational and communications services, and at NSTL for facilities operations, including security.

The requested funding for the ETB in FY 1984 provides for a continuation of the FY 1983 level of support for institutional research and development facilities and services at the centers. The increase in FY 1984 budget authority requirements over FY 1983 reflects the effects of inflation on wages and other costs and the absence of an unobligated funding carryover similar to that which reduced the FY 1983 new obligational authority requirements, as addressed above.

In research and test support, the JSC will provide a five-day, one-shift operation for the safety, reliability and quality assurance activities and for the engineering and development laboratories, such as the Shuttle Avionics Integration Laboratory, the Electronics Systems Test Laboratory, and the Water Immersion Facility. Present supporting activities at MSFC will be continued during FY 1984.

Data systems and flight support will provide a minimal core level of support based on a five-day, two-shift operation of the central computer facility at JSC.

Operations support funding will provide for the maintenance of technical facilities and equipment, chemical cleaning, engineering design, technical documentation and analysis, telecommunications, component fabrication, photographic support, and logistics support. Examples of specific services to be provided in 1984 include: (1) operation and maintenance of specialized electrical and cryogenic systems, and maintenance of test area cranes; (2) operation of shops to do metal refurbishing, anodizing, plating, stripping, and etching of selected items on in-house hardware; (4) engineering, installation, operation, and maintenance of closed circuit fixed and mobile television required for support and surveillance of tests; (5) photographic services, including still and motion picture processing, and audio-visual mission support; (6) fabrication of models, breadboards, and selected items of flight hardware; (7) technical documentation services, telecommunications, and graphics; (8) technical services in support of center operations including receipt, storage, and issue of research and development supplies and equipment and transportation services; and (9) management services in support of center operations, including data management, microfilming, and preparation of technical documentation. In addition, 1984 funds will provide the basic level of institutional support at NSTL for continuing Space Shuttle main engine testing activities.

In launch systems support, funds are required to continue investigations of the research and development technologies available to enhance launch site hardware, ground processing, and support systems.

PAYLOAD AND OPERATIONS SUPPORT EQUIPMENT

FISCAL YEAR 1984 FUNDING LEVEL

Payload operations	$30,600
Payload support equipment	22,600
Total	53,200

The payload operations and support equipment program objective is to centralize the provision of payload services, both unique and common, which are required beyond the standard Shuttle services. Payload operations provides unique hardware, analysis, and launch site services to support STS missions—including mission management of the Solar Maximum Mission retrieval/repair activities. Payload support equipment funds the development and acquisition of reusable ground support equipment required for a wide range of payloads including Spacelab. In addition, this program provides for the activation and operations of the Payload Operations Control Center (POCC) located at JSC; this facility enables command and control of Shuttle/Spacelab attached payloads.

Payload operations funding in FY 1984 is required to furnish continued payload services for currently scheduled NASA launches. Payloads receiving support during this year include the mission to retrieve and repair the Solar Maximum Mission spacecraft, Galileo, ISPM, TDRS, Space Telescope, SL-2 and SL-3.

FY 1984 funding for payload support equipment will be used for the development, test, and installation of mixed cargo and test equipment, on-site cargo transporter, and long lead initial spares. FY 1984 funding also provides for the operations and maintenance of the POCC which supports the early Spacelab missions.

ADVANCED PROGRAMS

FISCAL YEAR 1984 FUNDING LEVEL

Advanced programs	$25,000,000

The principal objective of advanced programs is to provide technical and programmatic data for the definition and evaluation of candidate future Office of Space Flight programs. Advanced programs activities have been the source of information for major new programs and systems including Apollo, Skylab, and Shuttle. Subsystem studies and supporting development activities are conducted to demonstrate the required performance and reliability improvements in order to reduce future program cost, schedule, and performance risks.

In FY 1983, the advanced programs effort will be focused on conducting system and subsystem studies and advanced development for the continued definition of free-flying and tethered space platforms to operate with the Shuttle as well as for potential use with a space station; the investigation of advanced systems, tools, and techniques for placement, retrieval, and maintenance/repair of spacecraft; the definition of advanced transportation vehicle concepts, including orbital transfer vehicles and Shuttle-derived launch vehicles; and the initial mission analyses and trade studies related to a space station.

In FY 1984, major emphasis will be placed on preliminary concept studies with funding of some key advanced development items. The major goal continues to be the definition of the systems architecture and system elements needed for potential space operations over the next twenty years. System options fall into three categories: platforms and facilities in both low-Earth orbit and geosynchronous orbit; orbital services such as satellite servicing; and advanced transportation. In the platforms program area, system concept studies and design trade-offs will be concentrated on platforms operating from and supported by a space station, and flexible carriers for payloads of opportunity for use with the Space Shuttle. Orbital services will focus on the uses of the Shuttle for satellite servicing near and remote from the Shuttle for large structures assembly and support; man-operated equipment, tools and techniques for satellite servicing near and remote from the Shuttle or a space station; and use of the orbiter to demonstrate refueling, servicing, and checkout of spacecraft on-orbit. The advanced transportation effort will define a reusable evolutionary upper stage concept to be based on the Shuttle and space station, as well as equipment studies of certain Shuttle derived Earth-to-orbit launch vehicle systems. Manned system tests and engineering evaluations of laboratory models of regenerative life support systems developed through FY 1983 will be performed. Prototype development, simulation, and tests will be implemented to investigate the utility and efficiency of new manned extra-vehicular and teleoperated systems. As part of construction operations, studies of assembly and repair of future satellites in space will be undertaken, as well as studies of extravehicular activity operations essential for platform maintenance.

In the space station studies area, a low-level effort will continue to explore requirements and operational concepts. This effort will take advantage of the results of activities continued from FY 1983 such as the mission analyses and architectural trade studies.

TETHERED SATELLITE SYSTEM

FISCAL YEAR 1984 FUNDING LEVEL

Tethered satellite system	$3,300,000

The Tethered Satellite System (TSS) will provide a new capability for conducting space experiments in regions remote from the Space Shuttle orbiter. By means of a closed-loop control system acting upon a tether, payloads of 200 to 500 kg can be deployed to distances of 100 km and held in a fixed position with respect to the orbiter. A number of significant scientific objectives can be uniquely undertaken with a TSS facility, such as: the observation of important atmospheric processes occurring within the lower thermosphere; new observations of crustal geomagnetic phenomena; the direct observation of magnetospheric-ionospheric-atmospheric coupling processes in the 125–150 km altitude region; and entirely new electrodynamic experiments and in situ observations in previously inaccessible regions. The TSS will be an international cooperative program with the Italian government. The United States will develop the deployment mechanism and will be responsible for overall program management and integration with the orbiter. Italy will develop the satellite and will also be responsible for instrument and experiment integration. The planning estimate for the total development cost for the United States activities is estimated at $40–$50 million. The TSS is scheduled to be available for launch in 1987.

The funding in FY 1984 will provide for the initiation of hardware development following advanced development activites conducted in FY 1983. It is our understanding that the Italian government has authorized all funds necessary to complete the development and flight of the satellite.

2. SPACE TRANSPORTATION OPERATIONS, $1,570,600,000

FISCAL YEAR 1984 FUNDING LEVEL

Flight Operations	$315,000,000
Flight Hardware	848,400,000
Launch and Landing Operations	357,200,000
Delta	50,000,000
Total	1,570,600,000

Space Transportation Operations provides the standard operational support services for both of the primary U.S. space launch systems: the Space Shuttle and the expendable launch vehicles. Within Shuttle operations, external tank and solid rocket booster flight hardware is produced; operational spare hardware is provisioned, overhauled and repaired; and the manpower, propellants, and other materials are furnished to conduct and support both flight and ground (launch and landing) operations. The Space Shuttle operations program provides for the launch of NASA, Department of Defense (DOD), other U.S. Government, domestic commercial and international missions. Five flights are planned for launch in FY 1983. Eight to nine missions are planned in FY 1984, depending upon reflight requirements and identification of new mission requirements. The Vandenberg launch site is planned to be activated on a schedule which would enable a first flight to take place as early as late 1985.

The Space Shuttle provides launch services to non-NASA users on a reimbursable basis; the amount paid by such users is tied to the size of the user's payload and the services required to support his launch requirements. For flights through FY 1985, the computation is based on a full mission cost for standard launch services of $18.0 million per flight in 1975 dollars; for FY 1986–1988 flights, the charge will increase to $38.0 million in 1975 dollars, or approximately $71 million in FY 1982 dollars. The budget is based on charging DOD $16.0 million in 1975 dollars for dedicated flights in FY 1984 and FY 1985, and $29.8 million in 1975 dollars for flights during FY 1986–1988. The Bureau of Labor Statistics computation of compensation per hour is used as the index for escalating 1975 dollars to current dollars for billing purposes. The projected receipts from reimbursable users are applied against total program funding requirements to derive the amount of appropriated funds requested.

The Shuttle operations budget requests fund three principal areas: flight operations, flight hardware, and launch and landing operations. Under flight operations is the training, mission control, and flight operations planning, payload integration analysis, mission analysis, and post-flight anomaly resolution; flight hardware includes the external tanks (ET), solid rocket boosters (SRB), main engine flight spares, orbiter spares (including overhaul, repair and logistics), and Marshall Space Flight Center (MSFC) systems support; and launch and landing operations covers Kennedy Space Center (KSC) operations, contingency landing site provisions, and Dryden Flight Research Facility (DFRF) operations.

The objective of the expendable launch vehicles program is to provide for the centralized procurement of launch vehicles and the launch support services for NASA's automated spacecraft missions, as well as for other agencies and organizations utilizing these systems and services on a reimbursable basis.

The expendable launch vehicle transportation systems consist of the Scout, the Atlas Centaur, the Delta, and the Atlas-F vehicles. This family of launch vehicles has been developed to support NASA's automated spacecraft launch requirements and, on both a cooperative and a reimbursable basis, to support other government, international, and commercial agencies and organizations. The expendable launch vehicle program includes the procurement of vehicle hardware, launch services, engineering, and maintenance support, including the necessary reliability improvements of the launch vehicle, and the ancillary ground equipment. In FY 1984, only the Delta requires appropriated funding; the Scout, Atlas-Centaur, and Atlas-F are on a fully reimbursable basis.

Expendable launch vehicles are launched from sites located at the Eastern Space and Missile Center (ESMC) in Florida, the Western Space and Missile Center (WSMC) in California, the Wallops Flight Facility in Virginia, and the San Marco Platform of the African coast near Kenya.

FLIGHT OPERATIONS

FISCAL YEAR 1984 FUNDING LEVEL

Mission support	$118,200,000
Integration	155,800,000
Support	41,000,000
Total	315,000,000

Shuttle operations funding is combined with the reimbursements received from other U.S. Government, commercial, and international users to support the launch and flight operations requirements of the Space Shuttle. Significant missions included in the early operations time frame are the first commercial satellites deployment in November 1982, the launch of the TDRS-A in early 1983, the first Spacelab flight in the fall of 1983, and the first dedicated launch of a DOD payload in late 1983.

Mission support includes a wide variety of planning activities ranging from operational concepts and techniques to detailed systems operational procedures and checklists. Tasks include preparation of development system and software handbooks, flight rules, detailed crew activity plans and procedures, development of Mission Control Center and network systems requirements, and operations input to the planning for the selection and operation of Shuttle payloads.

Specific flight planning activity encompasses the flight design, flight analysis, and software activities. The flight design tasks include supporting the crew training simulations and development of flight techniques. Flight design products include conceptual flight profiles and operational flight profiles which are issued for each flight. The software activities include the development, formulation, and verification support for the guidance, targeting, and navigation systems software requirements in the orbiter and Mission Control Center (MCC). In addition, the flight-dependent data located in the erasable memory (mission-to-mission changes) is developed from the flight design process for incorporation into the orbiter software, Shuttle mission simulator, and MCC systems.

Integration includes: the identification of operational requirements for the design of planned and improved spacecraft systems; the development of flight techniques for utilization of these systems; and conceptual level profile development and analysis, beginning about two years before the flight; and operational profile development and analysis, accomplished in the period immediately prior to the flight. Analytical integration is performed for payloads in the cargo bay and mid-deck and for Getaway Special cannisters, as are the engineering, testing and quality assurance necessary for system operations.

Support for flight operations ranges from the Johnson Space Center (JSC) base operations support to system activities at Headquarters and the Goddard Space Center (GSFC), to the effort associated with the system-wide improvements necessary to achieve the planned flight rate and schedule reliability required for mature system operations.

The Space Transportation System (STS) flight rate will nearly double in FY 1983 from the year before (from three in FY 1982 to five in FY 1983), and will nearly double again (to 8-9) in FY 1984. The program is transitioning from a developmental stage of operations into a mature operational phase. There are new capabilities being added to the program (new orbiters, different types of payload, different upper stages, lightweight external tanks, and higher performance solid rocket boosters) which make this a complex transition. The program is developing the reconfiguration tools in the software, mission planning and integration area so that the orbiters, the simulators and the MCC will be capable of carrying out training and operations involving the several additonal capabilities planned for introduction in this period.

The flight operations portion of the Shuttle operations budget sustains the maintenance and operation of the onboard avionics software and the mission control systems; maintenance and operations of the training and flight proficiency aircraft and simulators for crew training; and analysis and generation of the mission planning necessary to conduct and control the mission and instruct the flight crew. Flight operations also includes the sustaining engineering required to integrate all flight elements and to assure systems safety and integrity; the analytical integration of the payloads into the orbiter and the planning to assure compatibility and verification of interfaces; support of crew operations and training programs; and program support at JSC and NASA Headquarters. In addition, orbiter sustaining engineering manpower is required in support of the orbiter vehicle to insure maintainability, reliability, and anomaly resolution during operations; also, the amount required over the core engineering and technical base for the operations and maintenance of the Shuttle Avionics Integration Laboratory (SAIL) is provided to test and verify the ongoing operations software and hardware modifications. These configuration changes result from mission-unique requirements or system changes/redesigns intended to reduce costs. The SAIL is a key element in the capability of the system to investigate and resolve anomalies experienced on the ground or in flight. Also included is update and verification of flight software, post-flight assessment, and ground turnaround evaluation.

Further, flight operations includes the Getaway Special Support managed by GSFC for the payload integration activities at KSC, the flight crew mission requirements and timeliness, and the safety certification at JSC. Also, included are the operations and maintenance support, printing, equipment rentals and supplies, and materials for the base operations activities at JSC.

FLIGHT HARDWARE

FISCAL YEAR 1984 FUNDING LEVEL

Orbiter	$159,000,000
Solid rocket booster	353,200,000
External tank	336,200,000
Total	848,400,000

The flight hardware program element provides for the procurement of external tanks (ET); solid rocket motors, booster hardware, and propellants; spare components for the main engines; orbiter spares; sustaining engineering and logistics support for external tank/solid rocket booster/main engine flight hardware elements; and maintenance and operation of flight crew equipment. Included in the funding request for external tanks, solid rocket motors and boosters are the long-lead time raw materials, subassemblies, and subsystems necessary to sustain the production of these elements in a consistent manner with the increasing flight rate. Production phasing of these elements is based on the current flight traffic model and is structured to maintain as smooth and efficient a buildup of the production capability as possible. The procurement of some elements of the solid rocket booster (SRB) has, however, been accelerated to reflect the need for additional hardware to protect against the hardware attrition and refurbishment problems encountered during the orbital flight tests. In the ET, an efficient and nondisruptive production process is being developed which enables manufacturing, assembly, and checkout operations to proceed on a basis which allows for timely delivery of flight hardware to the launch site. The orbiter line element includes: main engine overhauls, procurement of replacement spare parts and attendant sustaining engineering; provision for the fixed level of annual support for the liquid hydrogen plant; orbiter spares for replenishment of line and shop replaceable units, and the manpower for supporting this logistics operation; and, replacement spares, field support, and maintenance of crew-related equipment. Some examples of orbiter spare equipment are fuel cells, tiles for thermal protection, tape recorders, leading edge support structures, wheels, brakes and pyrotechnics. The crew-related equipment activities include support to the pre-flight training and flight usage of the extra-vehicular maneuvering unit (EMU), emergency portable oxygen systems, radiation instrumentation, survival radios, closed-circuit television cameras, and food and other galley-related items.

Orbiter flight spares and crew equipment spares are based on calculations involving flight rates, maintenance schedules, operational hours, turnaround times, and lead times to procure spares.

Main engine hardware provides for manufacturing and delivery of engine component spares. Flight hardware production deliveries for the SRB and ET are based on lead times required to support the FY 1984 flight rate and also the necessary costing of materials and component hardware to start refurbishment and fabrication activities for flights in future years. Ten sets of SRB hardware and eleven ETs are scheduled for delivery to KSC in FY 1984.

LAUNCH AND LANDING OPERATIONS

FISCAL YEAR 1984 FUNDING LEVEL

Launch operations	$301,600,000
Payload and launch support	55,600,000
Total	357,200,000

Launch and landing operations provides for the launch preparations and the launch and landing operations of the Space Shuttle. The orbiter, ET, SEBs, main engines, and payloads are checked out, integrated, and launched from KSC at Cape Canaveral, Florida. The SRBs are retrieved from the Atlantic Ocean after separation from the Shuttle. Space Shuttle landing support is furnished at KSC, DFRF, and contingency landing sites. The major facilities used for launch and landing operations include: the orbiter processing facility, the vehicle assembly building, mobile launcher platforms, SRB processing and storage facility, payload processing facilities, launch pads, and the Shuttle landing facility.

Funding for launch and landing operations supports the manpower, ground support equipment, and propellants required to accomplish the integration and processing of the Shuttle and its payloads. Under launch operations, manpower is provided to process and integrate the orbiter, ET, solid rocket motors/boosters and the main engine into the proper launch configuration preparatory to each flight. Support manpower is also included to conduct the SRB retrieval operations, configuration control, transportation, inventory control and program support including operations and maintenance of the facilities and equipment. Funding for payload and launch support provides for the processing and integration of the payloads, procurement of spares for ground support equipment, propellants for launch operations and base support (excluding SRB propellants), and landing support at the DFRF.

The Shuttle's first operational flight (STS-5) occurred in November 1982. Turnaround times for the Shuttle hardware have rapidly decreased through the orbital flight tests (STS-1 through STS-4) and the inital operational flight, indicating that the system is capable of progressing over the next several years into a mature operational system able to handle the increasing flight rate. The multiple contractors used during the developmental phase to carry out Shuttle processing and base operations are being phased into two major contracts: a Shuttle processing contract (SPC) and a base operations contract (BOC). Consolidation of these contracts is viewed as a necessary means of reducing the manpower required for launch and landing operations and minimizing the degree of government involvement, thereby reducing the effective cost per flight. A single base operations contract was awarded in December

1982, and a request for proposals will be issued in early 1983 for a single Shuttle processing contract.

Launch and landing operations funding in FY 1984 provides for the manpower necessary to accomplish vehicle and payload processing to support the 8–9 launches planned for FY 1984. This includes manpower for the various Shuttle flight elements, support for the launch processing system (LPS) automatic checkout and launch operations capability, and sustaining engineering. Implementation of the Shuttle processing contract is scheduled for late 1983; the initial start-up costs and projected manpower savings are reflected in the estimate.

Payload and launch support will provide for the procurement of the spares for ground support equipment (such as hydraulic system valves, cryogen system pumps, replacement mobile launcher platform crawler shoes, and LPS magnetic tapes), propellants for launch operations and base support, contractor support for the maintenance of the cargo interface test equipment (CITE), payload integration manpower, and landing support requirements for landings at DFRF.

DELTA

FISCAL YEAR 1984 FUNDING LEVEL

Delta	$50,000,000

The Delta launch vehicle is the most widely used vehicle in NASA's expendable launch vehicle family. Since its first use in 1960, this vehcile has been utilized in 165 launches and has experienced a success record of over 92 percent. It is presently operational with two- and three-stage configurations. the first stage is an elongated Thor booster with three, six, or nine strap-on solid motors for thrust augmentation. The second stage Delta, which provides a multiple restart capability, uses an inertial guidance system for guiding the first stage booster and the second stage Delta. With the use of a Payload Assist Module (PAM/SSUS–D) solid motor attached to the spacecraft, this vehicle is capable of placing a 1,100 kilogram payload (2,400 pounds) or, in the 3920 configuration, a 1,270 kilogram (2,800 pounds) payload into a synchronous transfer orbit. This vehicle in its three-stage configuration is approximately 35 meters in length (115 feet) and has a diameter of 2.44 meters (8 feet).

The FY 1984 funding will be used to continue the Delta launch vehicle procurements initiated in prior years to support Landsat-D' and AMPTE NASA spacecraft requirements. Funds are also required for technical and engineering support to sustain vehicle test and checkout and launch operations, and to support maintenance of launch facilities and ground equipment.

This vehicle system, planned to be operational at least until 1986, is the most utilized of our current vehicles. It is being used to support user requirements, on a reimbursable basis, for launching missions for other U.S. Government, commercial, and international customers.

3. PHYSICS AND ASTRONOMY, $514,600,000

FISCAL YEAR 1984 FUNDING LEVEL

Space Telescope Development	$165,600,000
Gamma Ray Observatory Development	89,800,000
Shuttle/Spacelab Payload Development and Mission Management	92,900,000
Explorer Development	48,700,000
Mission Operations and Data Analysis	80,500,000
Research and Analysis	35,800,000
Suborbital Program	53,300,000
Total	566,600,000

The major objective of the Physics and Astronomy program is to increase our knowledge of the origin, evolution, structure, and composition of the universe, including the Sun, the stars, and the other celestial bodies. Space-based research is being conducted to investigate the structure and dynamics of the Sun and its long- and short-term variations; cosmic ray, X-ray, ultraviolet, optical, infrared, and radio emissions from stars, interstellar gas and dust, pulsars, neutron stars, quasars, black holes, and other celestial sources; and the laws governing the interactions and processes occurring in the universe. Many of the phenomena being investigated are not detachable from ground-based observatories because of the obscuring or distorting effects of the Earth's atmosphere.

To achieve the objectives of the Physics and Astronomy program, NASA employs theoretical and laboratory research; aircraft, balloon and sounding rocket flights; Shuttle-Spacelab flights; and free-flying spacecraft. Research teams involved in this program are located at universities, industrial laboratories, NASA field centers, and other government laboratories.

The scientific information obtained and the technology developed in this program are made available to the scientific communities for application to and the advancement of scientific knowledge, education and technology.

The Physics and Astronomy missions undertaken to date have been extraordinarily successful, and a number of missions continue to produce a rich harvest of data including the International Ultraviolet Explorer (IUE) and the Solar Maximum Mission (SMM).

Explorer satellites are relatively low cost missions which have been developed since the beginning of our country's space program. The Infrared Astronomical Satellite (IRAS), developed in collaboration with the Netherlands and the United Kingdom to conduct the first survey of the far infrared sky, is scheduled to be launched in early 1983. The IRAS telescope is surrounded by superfluid liquid helium which keeps it at a temperature of 4 degrees above absolute zero, giving the mission the sensitivity to observe the cool and cold objects of the universe. These objects include asteroids, regions of star formation, and non-thermal sources in some active galaxies which emit most of their radiation in the far infrared, the band between visible light, and microwaves. The International Ultraviolet Explorer has observed some very young stars, and these results are just now being applied to questions about the early history of the Earth. The Dynamics Explorers (DE) are continuing their investigations into the flow of energy into the Earth's magnetosphere; this information can be used to relate conditions at low latitudes to events occurring at high latitudes and far above the surface of the Earth. The Solar Mesosphere Explorer (SME) continues to relay data about the distribution of ozone high in the stratosphere; this data will be used to further our understanding of how it moves during the year as a result of solar activity.

In FY 1984, development activities on the Space Telescope will continue in preparation for launch in 1985. The detailed mechanical and electrical design of the Gamma Ray Observatory will be completed in FY 1984; Critical Design Reviews will be held on all the scientific instruments, and major hardware development will begin.

Two explorer missions are now under development, the Active Magnetospheric Particle Tracer Explorers (AMPTE) and the Cosmic Background Explorer (COBE). In addition, a U.S. X-ray high-resolution imager is being developed for launch on the Roentgen Satellite (ROSAT), which is being developed by the Federal Republic of Germany. Development of the Extreme Ultraviolet Explorer (EUVE) will also be initiated in FY 1984. EUVE will survey the sky in the last unmapped spectral band by covering the portion of the electromagnetic spectrum between ultraviolet and X-rays.

Suborbital observations will continue to be conducted in FY 1984 from balloons, sounding rockets, and high-flying aircraft that carry instruments above most of the atmosphere.

Two Spacelab payload missions, OSTA-1 and OSS-1, were successfully flown on Shuttle orbital flight tests. Spacelab 1 experiment integration activities have been completed in preparation for launch in September 1983, and significant progress has been made on development of the Spacelab 2 payload, the second of the two demonstration flights of the Spacelab hardware developed by the European Space Agency.

SPACE TELESCOPE DEVELOPMENT

FISCAL YEAR 1984 FUNDING LEVEL

Spacecraft	$145,400,000
Experiments	20,200,000
Total	165,600,000

The Space Telescope will make a major contribution to understanding the stars and galaxies, the nature and behavior of the gas and dust between them, and the broad question of the origin and scale of the universe. Operating in space above the atmospheric veil surrounding the Earth, the Space Telescope will increase, by several hundredfold, the volume of space accessible for observations. With its significant improvements in resolution and precision in light sensitivity and in wavelength coverage, the Space Telescope will permit scientists to conduct investigations that could never be carried out with ground-based observatories limited by the obscuring and distorting effects of the Earth's atmosphere.

The Space Telescope will enhance the ability of astronomers to study radiation in the visible and ultraviolet regions of the spectrum. It will be more sensitive than ground-based telescopes and will allow the objects under study to be recorded in greater detail. It will make possible observations of objects so remote that the light will have taken many billions of years to reach the Earth. As a result, we will be able to look far into the distant past of our universe. The Space Telescope will also contribute significantly to the study of the early state of stars and the formation of solar systems, as well as the observation of such highly-evolved objects as supernova remnants and white dwarf stars. With the Space Telescope we may be able to determine the nature of quasars and the processes by which they emit such enormous amounts of energy; it may also be possible to determine whether some nearby stars have planetary systems with the Space Telescope.

The Space Telescope will be an automated observatory, delivered into orbit by the Space Shuttle. Data from its scientific instruments will be transmitted to Earth via the Tracking and Data Relay Satellite System. The Space Telescope design will permit in-orbit maintenance and repair, and/or retrieval by the Space Shuttle for return to Earth for required refurbishment and then relaunch by the Space Shuttle.

During FY 1982 the primary and secondary mirrors were coated and assembly of the primary mirror and its support equipment was begun. Fabrication of all scientific instruments has been completed; instrument assembly and environmental testing is underway. The Support Systems Module Critical Design Review was conducted, and fabrication of that major element is now in progress.

In 1983, the primary assembly will be completed and integration of the Optical Telescope Assembly (OTA) will be initiated. The scientific instruments will be delivered for verification and acceptance testing. The Support Systems Module (SSM) will also be completed.

The FY 1984 funding is required to complete the final integration and testing of the Optical Telescope Assembly, the Support Systems Module, and the scientific instruments. In addition, FY 1984 funding is required for integration and testing of the total Space Telescope system in preparation for the launch scheduled for 1985.

GAMMA RAY OBSERVATORY DEVELOPMENT

FISCAL YEAR 1984 FUNDING LEVEL

Spacecraft	$70,900,000
Experiments	18,900,000
Total	89,800,000

The objective of the Gamma Ray Observatory mission is to measure gamma radiation from the universe, and to explore the fundamental physical processes powering it. Certain celestial phenomena are accessible only at gamma ray energies. The observational objectives of the Gamma Ray Observatory are to search for direct evidence of the synthesis of the chemical elements; to observe high energy astrophysical processes occurring in supernovae, neutron stars and black holes; to locate gamma ray burst sources; to measure the diffuse gamma ray radiation for cosmological evidence of its origin; and to search for unique gamma ray emitting objects.

Gamma rays represent one of the last frontiers of the electromagnetic spectrum to be explored because the required technology has only recently been developed. The low flux levels of gamma ray quanta, and the high background they produce through their interaction with the Earth's atmosphere, coupled with the demand for better spectral, spatial and temporal resolution of source features, combine to require that large gamma ray instruments be flown in space for a prolonged period. Gamma rays provide unique information on the most intriguing astronomical objects yet discovered, including quasars, neutron stars, and black holes. Astronomy is now at the point where our understanding of these objects is seriously impaired by lack of data in the gamma ray region of the spectrum. comprehensive research in gamma ray astronomy has consistently been given high priority by the science community.

The Gamma Ray Observatory is scheduled for launch by the Space Shuttle in 1988. The spacecraft is being designed to accommodate four large gamma ray instruments, and will be designed to allow retrievability by the Space Shuttle. The instruments will have their principal axis pointing in the same direction, and the spacecraft will point these instruments in a fixed direction in space for long periods (hours to weeks).

In fiscal year 1982, procurement was initiated on long-lead items for the scientific instruments Configuration drawings, resulting from studies of instrument placement and thermal requirements were completed. Preliminary interfaces with the scientific instruments, the Space Shuttle, and the Tracking and Data Relay Satellite System were defined. In fiscal year 1983, preliminary design reviews for the scientific instruments will be completed; and procurement of long-lead spacecraft hardware will be initiated. Work will continue in fiscal year 1983 on detailed definition of interfaces with the Space Shuttle, and Spacecraft design will be well underway.

The fiscal year 1984 funding is required to complete the detailed mechanical and electrical designs; complete the critcal design reviews on the scientific instruments; and complete the spacecraft preliminary design review. Spacecraft and scientific instruments hardware fabrication will also be initiated in fiscal year 1984.

SHUTTLE, SPACELAB PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT

FISCAL YEAR 1984 FUNDING LEVEL

Payload Development and Mission management	$92,900,000

The objectives of Spacelab payload development and mission management are to acquire new knowledge in the disciplines of physics and astronomy, to develop instruments for materials processing experimentation, and to manage the mission planning and execution of all NASA Spacelab payloads. This funding is required for the development of all physics and astronomy experiments, system management and engineering development of flight equipment and software; payload specialist training and support; physical integration of the payloads with the Spacelab system; operation of the payload in flight; dissemination of the data to experimenters; analysis of physics and astronomy flight data. In addition, this project funds the mission management effort for all NASA Spacelab payloads.

Instruments to be flown on four missions with primary emphasis on physics and astronomy are now under development. Spacelab-1, which will consist of a pressurized module and a pallet, is scheduled for launch in 1983. The objectives of Spacelab-1 are to demonstrate the capabilities of the Spacelab system and to obtain multidisciplinary scientific data with emphasis on atmospheric and space plasma physics, as well as life sciences. Spacelab-1 is a cooperative mission with the European Space Agency. In 1983, the Spacelab-1 instruments will be integrated into the Spacelab module and pallet system and then into the Shuttle. Spacelab-2, a pallet-only configuration, is scheduled to fly in early 1985. The objective of Spacelab-2, the second of the two demonstration Spacelab flights, is to verify the Spacelab igloo and pallet systems and obtain scientific data with emphasis on astrophysics and solar physics. The Instrument Pointing System, developed by the European Space Agency, will be flown for the first time on the Spacelab-2 mission. During FY 1983, development of the Spacelab-2 instruments will be completed and integration will be initiated.

The OSS-5 mission is also under development with launch scheduled for 1986. OSS-5 is a Spacelab pallet payload consisting of three ultraviolet telescopes that will carry out ultraviolet imaging, spectrophotometry, and polarimetry at resolutions and sensitivities previously unavailable. This payload will allow unique new scientific investigations of a broad range of objects from nearby comets and planets to the most distant quasars. Data gathered by the OSS-5 mission will be used to define and direct future Space Telescope observations. The first flight of this mission will occur during the period of Halley's Comet and will allow unique scientific observations of the comet from a near-Earth orbital environment.

The Solar Optical Telescope (SOT) facility instrument definition and early design is now underway. The SOT will have a broad scientific capability and will accommodate a number of principal investigator-furnished focal plane or ancillary instruments.

Definition and development schedules of all physics and astronomy instruments are phased to form scientifically focused payloads. Instruments currently under development will be refurbished and reflown on future Spacelab missions, thereby significantly increasing the scientific value of the original investment. The hardware development efforts for the Fluid Experiment System/Vapor Crystal Growth payload are now being funded under this area to be more consistent with the Space Science and Applications organizational responsibilities. It was previously funded under the Materials Processing activities within Space Applications.

At the Kennedy Space Center, a system has been established to assemble Spacelab hardware to form a mission payload and to test the integrated system. Mission management activities are continuing on several space science and applications and space technology missions, as is planning for the first dedicated Life Sciences Spacelab mission.

In FY 1984, mission management of the ongoing Spacelab missions will be continued. Mission management for the non-physics and astronomy missions includes all Spacelab payload efforts except instrument development and data analysis. FY 1984 funding is also required to continue development of instruments for materials processing experimentation including the Fluid Experiment

System/Vapor Crystal Growth experiment, which is planned for flight on Spacelab-3.

FY 1984 funding is required for analysis of data from the Spacelab-1 mission, as well as integration and test activities on the Spacelab-2 payload, leading to a launch in 1985. Development will continue in FY 1984 on the instruments for the OSS-5 mission as well as on the Solar Optical Telescope. Early definition activities will be continued on the Shuttle Infrared Telescope Facility. FY 1984 funding is also required to define potential payloads for a future Space Station.

EXPLORER DEVELOPMENT

FISCAL YEAR 1984 FUNDING LEVEL

Infrared astronomical satellite	
Active magnetospheric particle tracer explorer	$4,300,000
Cosmic background explorer	26,300,000
Roentgen satellite	2,000,000
Extreme ultraviolet explorer	11,000,000
Other explorers	5,100,000
Total	48,700,000

The Explorer program provides the principal means of conducting astronomical studies and long-term investigations of solar physics and of the near-Earth interplanetary environment, having limited specific objectives and not requiring major observatories. Included in the present program are studies of the atmospheric and magnetospheric physics; the several magnetospheric boundaries; interplanetary phenomena; and X-ray, ultraviolet and infrared astronomy. Studies are conducted to define future high priority science explorer missions. NASA engages in cooperative missions with other Federal agencies and other nations whenever such cooperation will assist in achieving the mission objectives.

Solar terrestrial and atmospheric explorers provide the means for conducting studies of the Earth's near-space environment. The program requires a wide variety of satellites in orbits extending from the very lowest reaches of the upper atmosphere to the interplanetary medium beyond the Earth's magnetosphere. Efforts in FY 1983 include launch of the Infrared Astronomical Satellite, launch of the San Marco-D mission, and continuation of development on the Active Magnetospheric Particle Tracer Explorer. The San Marco-D mission, a cooperative project with Italy, will include a group of United States experiments to study the relationship between solar activity and the Earth's meterological phenomena. The Infrared Astronomical Satellite, a cooperative project with the Netherlands and the United Kingdom, is expected to record precise flux levels and locations of over a million infrared sources in the universe. The Active Magnetospheric Particle Tracer Explorer, a cooperative project with the Federal Republic of Germany, will involve the use of two spacecraft, one designed and built by the United States and one designed and built by Germany. The mission will study the solar wind at the subsolar point and will identify particle entry windows, energization processes and transport processes into the magnetosphere.

Astrophysics explorers have been instrumental in conducting the first astronomical sky surveys in the gamma ray, X-ray, ultraviolet and and low frequency radio regions of the electromagnetic spectrum. The Cosmic Ray Isotope Experiment, which was launched in May 1982 on a Department of Defense spacecraft, is studying galactic cosmic rays, as well as nuclei accelerated from solar flares, in order to shed light on models of nucleosynthesis and to identify probable sources of cosmic ray nuclei. Development will continue on the Cosmic Background Explorer (COBE) and on the instrument to be flown on the German Roentgen Satellite (ROSAT). COBE will carry out a definitive, all-sky exploration of the diffuse cosmic background radiation of the universe between the wavelengths of 1 micrometer and 13 millimeters. The detailed information this mission will provide on the spectral and spatial distribution of low energy background radiation is expected to yield significant insight into the basic cosmological question of the origin and evolution of the universe. ROSAT, a cooperative project between the Federal Republic of Germany and the United States, will perform high resolution imaging studies of the X-ray sky. The United States will provide a high resolution imaging instrument and launch services, and Germany will provide the spacecraft and instrumentation.

FY 1983 funding is also supporting definition studies for future candidate explorer missions, including the Extreme Ultraviolet Explorer which will be initiated in FY 1984, the X-Ray Timing Explorer, and instrumentation to be flown on the reflight of the Long Duration Exposure Facility which will be a Cosmic Ray Mission.

FY 1984 funding is required for continued development activity on the Atmospheric Particle Tracer Explorer, the Cosmic Background Explorer, and instrumentation to be flown on the German Roentgen Satellite, as well as initiation of development on the Extreme Ultraviolet Explorer. The Extreme Ultraviolet Explorer will carry out the first detailed all sky survey of ultraviolet radiation between 100 and 900 angstroms—a hitherto unexplored portion of the electromagnetic spectrum. FY 1984 funding will provide for definition studies of potential future explorer missions such as the X-ray Timing Explorer.

MISSION OPERATIONS AND DATA ANALYSIS

FISCAL YEAR 1984 FUNDING LEVEL

High energy astronomy observatory extended mission	$6,000,000
Solar maximum mission extended mission	2,100,000
Solar maximum mission retrieval/repair mission	6,300,000
Space telescope operations	38,000,000
Space telescope maintenance and refurbishment	13,500,00
Explorers	14,600,000
Total	80,500,000

The purpose of the mission operations and data analysis effort is to conduct operations and analyze data from the physics and astronomy satellites after launch. The program also supports the continued operation of a number of spacecraft after their originally planned objectives have been achieved, for purposes of conducting specific investigations that have continuing, high scientific significance. The funding supports the data analysis activities of the many investigators at universities and other research organizations associated with astrophysics and solar terrestrial operational satellite projects. Actual satellite operations, including operation control centers and related data reduction and engineering support activities, are typically carried out under a variety of mission support or center support contracts.

Several spacecraft remain operational. The International Ultraviolet Explorer continues to perform well, with a very productive guest investigator program. The Solar Maximum Mission (SMM) also continues to provide useful data, even though it is operating in a degraded mode. Mission operations and data analysis will continue for these missions through FY 1983, as well as for the Infrared Astronomical Satellite, which will be launched in early 1983. FY 1983 funding also supports activities leading to the retrieval/repair of the SMM spacecraft and science instruments in 1984.

In addition to the normal support required for mission operations, the Space Telescope program encompasses several unique aspects which must be provided for well in advance of launch. The Space Telescope is designed for operation for more than a decade, using the STS for in-orbit maintenance, refurbishment, and in-orbit change out of the scientific instruments as well as periodic retrieval, return to Earth for complete refurbishment, and then relaunch by the Space Shuttle. During the operational period, the Space Telescope will be used primarily by observers selected on the basis of proposals submitted in response to periodic solicitations. Science operations will be carried out through an independent Space Telescope Science Institute. The institute will operate under a long-term contract with NASA. While NASA will retain operational responsibility for the observatory, the institute will implement NASA policies in the area of planning, management, and scheduling of the scientific operations of the Space Telescope.

FY 1984 funds will provide support for the basic mission operations and data analysis activities for the infrared Astronomical Satellite and the Active Magnetospheric Particle Tracer Explorer, continued operations and data analysis activity for the International Ultraviolet Explorer, and continued analysis of the extensive data obtained by the High Energy Astronomy Observatory missions. FY 1984 funding will support the retrieval/repair of the Solar Maximum Mission spacecraft and instruments, and will support preparations for the operation of the space Telescope. In FY 1984, the development of mission operations procedures as well as development of the science operations ground system for the Space Telescope will be continued. the Space Telescope Science Institute will progress toward becoming operational through the continued development of the Guide Star Selection System and Science Data Analysis Software. In FY 1984, maintenance and refurbishment planning activities such as the purchase of orbital replacement units and space support equipment will be continued to allow for the capability to service the Space Telescope in orbit.

RESEARCH AND ANALYSIS

FISCAL YEAR 1984 FUNDING LEVEL

Supporting research and technology	$24,900,000
Advanced technology devclopment	4,700,000

Data analysis	6,200,000
Total	35,800,000

This program provides for the research and technology base necessary to define, plan and support flight projects. Preliminary studies to define missions and/or payload requirements are carried out, as are theoretical and ground-based supporting research and advanced technology development (ATD). Activities included are supporting research and technology (SR&T), ATD, and data analysis.

Supporting Research and Technology (SR&T).—The objectives of the supporting research and technology area are to: (1) optimize the return expected from future missions by problem definition, development of advanced instrumentation and concepts, and sound definition of proposed new missions; (2) enhance the value of current space missions by carrying out complementary and supplementary ground-based observations and laboratory experiments; (3) develop theories to explain observed phenomena and predict new ones; and (4) strengthen the technological base for sensor and instrumentation development and conduct the basic research necessary to support our understanding of astrophysics and solar-terrestrial relationships.

Research is supported in the disciplines of astronomy, astrophysics, and solar and heliospheric physics. Research in astronomy and astrophysics involves the study of stars, galaxies, interstellar and intergalactic matter and cosmic rays. The work in solar and heliospheric physics involves the study of the solar atmosphere and the influence of the Sun on interplanetary phenomena. The development of new instruments, laboratory and theoretical studies of basic physical processes, and observations by ground-based and balloon-borne instruments are also supported. Results achieved in the SR&T program have a direct bearing on future flight programs. For example, the development of advanced X-ray and ultraviolet astronomy imaging devices under this program will enable spacecraft to carry instruments for astronomical observations which have increases of orders of magnitude in sensitivity and improved resolution over currently available detectors.

The SR&T program carries out its objectives through universities, non-profit and industrial research institutions, NASA centers and other government agencies. Current emphasis is being placed on studies of advanced instrumentation with increased sensitivity and resolution.

Advanced Technological Development (ATD).—The advanced technological development activities support detailed planning and definition of new potential physics and astronomy missions. ATD activities assure that future missions address the scientific questions most important to the evolution of knowledge in the field, and that those missions use the appropriate technology and techniques. Funding is applied to the definition and preliminary design for specific missions or subsystems and elements critical to eventual mission development in order that technical readiness and resources may be adequately defined before the missions are proposed for implementation.

Candidate missions for the 1980's and early 1990's that require ATD activities include the Advanced X-Ray Astrophysics Facility

(AXAF), the Solar Internal Dynamics Mission (SIDM), and the Starprobe. The AXAF mission, which is the first priority mission recommendation of the National Academy of Sciences, will study stellar structure and evolution, active galaxies, cluster of galaxies and cosmology. The AXAF's 1.2 meter class imaging X-ray telescope is planned to have a sensitivity approximately 100 times that of HEAO-2 and a resolution increase of nearly a factor of twenty. The SIDM will observe the oscillations visible on the Sun and use the data to investigate the dynamics of the Sun's interior to provide insight into solar and stellar interior structure. The Starprobe mission will perform detailed scientific observations of the Sun from a highly elliptical orbit whose aphelion will be within three solar radii of the Sun's surface.

Major Spacelab payloads being considered for future proposal and requiring advanced technological development support include the following multiuser facilities: the Pinhole/Occulter Facility, a coded mask and detector for imaging hard X-rays; and the Shuttle Ultraviolet/Optical Telescope (STARLAB), a meter-class ultraviolet/optical facility which will be used for high angular resolution imaging investigations of sources that have too great an angular extent to be observed efficiently with the Space Telescope. During FY 1983, major emphasis is being given to definition of the AXAF mission, while definition work is also continuing on Spacelab instruments and facilities, including detailed description of payload configurations and operational requirements.

Data Analysis.—The acquisition, analysis and evaluation of data represents the primary purpose of the laboratory, balloon, rocket and spacecraft activities. While a considerable amount of analysis is done during the prime project phase, experience has shown that considerably more time is required to reap the full benefit from these programs. This will come about only when the data are correlated with other projects, when detailed cause-and-effect studies are made with data sets from other sources, when very long-term (e.g., one solar cycle) effects can be studied by using complementary sets of data, and when new ideas that originate from the results of the initial analysis can be tested. For example, astronomical image processing facilities have been developed to take advantage of high technology developed under the Landsat and planetary programs. This technology allows astronomers to extract a maximum amount of information from the data they obtained from standard photographic emulsions and more advanced imaging techniques such as the charge-coupled devices (CCD's) now being ground-tested for use on the Space Telescope.

Operation of the National Space Science Data Center (NSSDC) is also supported under this program. The NSSDC, LOCATED AT THE Goddard Space Flight Center, was estalbished to serve as a central repository and clearing house for scientific data resulting from space investigations. The NSSDC is now in a state of transition from a repository to a facility where correlative research can be accomplished by using data set from many sources, including active spacecraft, so that data acquisition and analysis efforts can be coordinated at times when several spacecraft are favorably situated for correlative geophysical studies.

During fiscal year 1984, the supporting research and technology program will support those tasks which contribute to maintaining a firm base for a viable physics and astronomy program. Emphasis will be placed on infrared detectors, gamma ray spectrometers and instrumention. Emphasis will also be placed on the development of a large array multichannel plate, and on intensified charge-coupled imagery devices. In the area of solar physics, activities will support the Solar Maximum Mission, especially through theoretical studies of high energy phenomena. New thrusts will be initiated in the development of advanced generation instrument concepts, especially for the extreme ultraviolet and x-ray wavelengths, and for analyzing the structure and dynamics of the solar interior.

In the data analysis activities to be carried out at universities and government research centers in fiscal year 1984, emphasis will be placed on correlative studies involving data acquired from several sources (spacecraft, balloons sounding rockets, research aircraft and ground observatories). Fiscal year 1984 funds will also support the continued operation of the National Space science Data Center at the Goddard Space Flight Center. In addition, fiscal year 1984 funding will support continued feasibility and scientific definition studies on future potential candidate missions such as the Advanced X-ray Astrophysics Facility, Gravity Probe-B, the Starprobe and the Solar Internal Dynamics Mission, as well as the definition of new Spacelab payloads.

SUBORBITAL PROGRAMS

FISCAL YEAR 1984 FUNDING LEVEL

Sounding rockets	$27,700,000
Airborne science and applications	18,900,000
Balloon program	6,700,000
Total	53,300,000

The suborbital program provides versatile, relatively low cost research through the use of balloons, aircraft, and sounding rockets to study the Earth's ionosphere and magnetosphere, space plasma physics stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a domestic and an international cooperative basis.

Sounding Rockets

A primary objective of the sounding rocket program is to support a coordinated research effort. Sounding rockets are uniquely suited for performing low altitude measurements (between balloon and spacecraft altitude) and for measuring vertical variations of many atmospheric parameters. Special areas of study supported by the sounding rocket program include the nature, characteristics, and composition of the magnetosphere and near space; the effects of incoming energetic particles and solar radiation on the magnetosphere, including the production of aurorae and the coupling of energy into the atmosphere; and the nature, characteristics, and spectra of radiation of the Sun, stars and other celestial objects.

Additionally, the sounding rocket program provides the physics and astronomy program with the means for flight testing instruments and experiments being developed for later flight on the Shuttle/Spacelab and space probes, and for calibrating and obtaining vertical profiles in concert with current orbiting spacecraft.

In FY 1982, 45 rockets were launched from six launch ranges located in the United States, Canada, and Norway. These rockets supported the research activities of about 27 groups from over 20 universities, private industry, NASA field centers, other government agencies and foreign space organizations.

During FY 1982 an astronomy sounding rocket payload, using a prototype telescope, obtained the first ultraviolet image of a barred spiral galaxy, Messier #83. This observation is significant in that the results indicate the presence of a massive black hole, whereas ground observations show a very ordinary galaxy. Additional sounding rocket activity, in support of auroral studies, has produced new results showing that X-rays are produced from electrons striking the upper atmosphere and that large electrical fields exist in the middle atmosphere. The origin of these fields remains a mystery.

Sounding rocket support for the area of plasma physics will continue to be of significant importance in FY 1983, with a coordinated international campaign of launches planned from Peru. These investigations will provide correlative data on the Earth's magnetosphere.

In FY 1983, emphasis is being placed on a sounding rocket payload concept called "Spartan". Under this concept, the capabilities of the Shuttle are made available to sounding rocket experiments, which will potentially increase scientific data acquisition periods from the present five minutes per flight up to 40 hours. The Spartan concept calls for sounding rocket scientific instrumentation and support hardware to be carried aloft by the Shuttle as free-flying payloads, and then returned by the Shuttle. These payloads require a minimum interface with the Shuttle. Development efforts on two payloads are being conducted in FY 1983, one for high energy astrophysics and one for solar astronomy.

FY 1984 funds will provide for continuation of the efforts described above, including development activity leading to a planned initial launch of a Spartan payload in 1984.

Airborne Science and Applications

Research with instrumented jet aircraft has been an integral part of the overall NASA program in physics and astronomy since 1965. For astronomy research, the airborne science and applications program utilizes a C–141 instrumented with the 91-centimeter infrared telescope. The C–141A "Kuiper Airborne Observatory," which began operational flights in 1974, is a full-scale, manned facility. This aircraft provides a large payload capacity and facilities for extending observations over any region of the Earth, and can operate at high altitudes (nearly 13 kilometers), in order to provide a cloud-free site for auroral geophysics experiments and astronomical observations. The possibility of conducting observations at this altitude, above most of the infrared-absorbing water vapor of the Earth's atmosphere, has been essential in opening the infrared region of the electromagnetic spectrum from one micrometer to hundreds of micrometers to astronomy.

In FY 1982, 62 flights were flown to make far-infrared observations. In FY 1983, approximately 72 flights of the C-141 will be made to continue exploration in the star-forming regions. A scientific highlight will be an expedition to Australia to observe the center of our own galaxy in the far infrared.

This program also provides flight support to other major segments of the Space Science and Applications program, with an aircraft fleet currently consisting of two U-2C's, one ER-2, one C-130, and one CV-990, in addition to the C-141A. These aircraft serve as test beds for newly developed instrumentation and permit the demonstration of new sensor concepts prior to their flight on satellites. The data acquired during these flights are used to refine algorithms and develop ground data handling techniques. Examples of such activities are flights over test sites to obtain crop signature data for the AgRISTARS program by the C-130, and flights in the ER-2/U-2C's to acquire simulated thematic mapper data. A principal use of the ER-2/U-2C's is to acquire stratospheric air samples and conduct in situ measurements at altitude ranges above the capability of more conventional aircraft and below that of orbiting spacecraft. This use is important in the study of stratospheric transport mechanisms wherein it is extremely desirable to penetrate the stratospheric region which, in the tropical interconvergence zone, is normally found at altitudes of 60,000 feet and above.

In FY 1984, airborne science and applications funding will be used to continue the operation of the Kuiper Airborne Observatory, to support astronomical groups, and to continue the development of improved instrumentation for conducting infrared astronomy.

Balloon Program

For the development of scientific experiments for space flight and for independent scientific missions, it is desirable to test the instrumentation in the space radiation environment and to make observations at altitudes which are above most of the obscuring effects of the atmosphere, particularly for observations in infrared and cosmic ray astronomy. In many instances it is necessary, because of size and weight, as well as low cost, to fly these experiments on balloons.

The balloon program funding is required for purchase of balloons, helium, launch services, tracking and recovery, and maintenance and operation of the National Scientific Balloon Facility (NSBF) at Palestine, Texas. This facility supports the launch of over 95 percent of NASA's balloon payloads. It is the nation's primary means for carrying out large scientific balloon operations. NASA took over funding responsibility for the NSBF from the National Science Foundation at the beginning of FY 1983. Funding for the experiments which are flown on these balloons is provided from supporting research and technology programs.

In FY 1982, 54 balloons were flown from launch sites in the United States, Brazil, and Australia. Over 90 percent of the flights originated from the United States. Launches from the southern hemisphere permit viewing of the galactic center, a prime area of interest to high energy astrophysics investigators. Results from these flights have provided clear evidence which supports the possibility that a massive black hole exists in the center of our galaxy.

During September 1982, a major balloon campaign was launched from Palestine, Texas, in support of atmospheric chemistry investigations. This seven-nation cooperative program to measure chemical constituents in the stratosphere required the launch of four heavy lift balloon payloads within three and one-half hours. This program, known as the Balloon Intercomparison Campaign, is significant in that it provided a complete set of measurements on key chemical constituents of a well defined air mass.

In FY 1983, approximately 50 balloon flights are planned to continue scientific research in the areas of atmospheric chemistry, high energy astrophysics, galactic astronomy and solar studies. The Balloon Intercomparison Campaign will be continued to study the chemical constituents of the stratosphere, and a high energy astrophysics program of observations of the galactic center will be continued.

The FY 1984 funding will provide for the continuation of the balloon program as well as management and operation of the NSBF. This funding is also required to continue concept definition activities for potential future long duration balloon flights.

4. PLANETARY EXPLORATION, $220,400,000

FISCAL YEAR 1984 FUNDING LEVEL

Galileo development	$79,500,000
Venus radar mapper mission	29,000,000
International solar polar mission	8,000,000
Mission operations and data analysis	43,400,000
Research and analysis	60,500,000
Total	220,400,000

The Planetary Exploration program includes the scientific exploration of the solar system, including the planets and their satellites, comets and asteroids, and the interplanetary medium. The program objectives are to understand the origin and evolution of the solar system, to better understand the Earth through comparative studies with the outer planets, and to understand how the appearance of life in the solar system is related to the chemical history of the solar system. The projects undertaken in the past have been highly successful. The strategy that has been adopted calls for a balanced emphasis on the terrestrial-like inner planets, the giant gaseous outer planets, and the small bodies (comets and asteriods). Missions to these planetary bodies start at the level of reconnaissance to achieve fundamental characterization of the bodies and proceed to a level of detailed study. The reconnaissance phase of inner planet exploration began in the 1960's and has now been completed, though we still known little about the nature of the planet Venus' surface. Mars has provided program focus because of its potential as a site of biological activity. The Viking landings in 1976 carried the exploration of Mars forward to a new level of scientific and technological achievement, thereby setting the stage for the next step of detailed study. Analyses of the moon rock samples returned by Apollo continue to be highly productive as new insights into the early history of the inner solar system are achieved and our theoretical concepts are revised accordingly. The continuing Pioneer Venus mission is carrying the study of our nearest neighbor and closest planetary analogue beyond the reconnaissance stage to the point where we have produced a basic characterization of the massive cloud-covered atmosphere of Venus. The characterization has also provided some fundmental data about the formation of the planet.

The exploration of the giant outer planets began relatively recently. The Pioneer-10 and 11 flybys of Jupiter in 1973 and 1974 were followed by the Voyager-1 and 2 spacecraft. Voyager-1 encountered Jupiter in March 1979 and Saturn in November 1980. Voyager-2 flew by Jupiter in July 1979 and Saturn in August 1981. New data on the plants, satellites and rings have revolutionized our concepts of the formation and evolution of the solar system. The Voyager-2 spacecraft is headed for an encounter with Uranus in 1986 that will further our knowledge of the giant outer planets as well as capitalize on the significant scientific, engineering and financial investment made in the development of the Voyager systems. The Pioneer-10 and 11 and Voyager-1 spacecraft are on trajectories leading out of the solar system, and they continue to return scientific data on the outer reaches of the solar system. Our scientific knowledge of the outer planets has increased greatly in less than a decade. Now, the Pioneer-10 and 11 and Voyager-1 spacecraft are on escape trajectories from the solar system as they continue to monitor their uncharted environments. The Voyager-2 spacecraft is headed for an encounter with Uranus in 1986.

The Galileo mission is a cooperative effort between the United States and the Federal Republic of Germany. A wide range of science experiments, chosen to make maximum progress beyond the Voyager findings, has been selected. The Galileo development efforts are proceeding on schedule for a 1985 launch.

The Galileo mission will be launched to Jupiter in 1986 by the Space Shuttle/Centaur Upper Stage. The payload is expected to extend our knowledge of Jupiter and its system of satellites beyond the profound discoveries of the Voyager and Pioneer missions. During twenty months of operation in the Jovian system, Galileo will have the capability to provide six satellite encounters, and an instrumented probe will be injected into Jupiter's atmosphere.

The Venus Radar Mapper (VRM) mission, which will be initiated in FY 1984, will focus on the cloud-shrouded surface of Venus. The VRM, using a synthetic aperture radar, will obtain global radar imagery of Venus with resolution sufficient to address fundamental questions regarding the origin and evolution of the plant, and will obtain altimetric and gravity data to determine accurately the gravity field, internal stresses, and density variations of the planet's interior. This date will be analyzed so that the evolutionary history of Venus can be compared with the Earth's. The VRM is scheduled for launch in 1988.

The International Solar Polar Mission (ISMP) is a joint NASA and European Space Agency endeavor that will fly a package of experiments outside the solar ecliptic plane. The ISPM, which will provide data on the effects of solar activity on the Earth, will be launched in 1986 on the Shuttle/Centaur Upper Stage.

In addition, the Planetary Exploration program is founded on a coordinated research and analysis program. Research and analysis activities will continue to be undertaken to maximize the scientific return from ongoing and future missions, such as lunar sample and meteroite analysis, ground-based telescope observations, theoretical and laboratory studies, and instrument definition. The highest scientific standards are maintained in these programs and both new and old concepts are subject to intense scrutiny. This program also involves interdisciplinary coordination among various research groups and the scientific results are widely disseminated. A close coupling is maintained between the reserch programs and the planning activities that are undertaken to define the scientific rationale and technology needed for potential future missions.

GALILEO DEVELOPMENT

FISCAL YEAR 1984 FUNDING LEVEL

Spacecraft	$48,800,000
Experiments	4,500,000
Ground operations	26,200,000
Total	79,500,000

The objective of the Galileo program is to conduct a comprehensive exploration of Jupiter, its atmosphere, magentosphere, and satellites through the use of both remote sensing by an orbiter and direct measurements by an atmospheric probe. The Galileo mission, which will conduct direct and long-duration studies of Jupiter, is a vital link in providing the continuity, balance, and orderly progression of the exploration of the solar system.

The Galileo mission will be accomplished with a single launch of both the orbiter and probe by the Shuttle/Centaur in 1986. Arrival at Jupiter will be in late 1988. The orbiter will provide remote sensing of the probe entry site and provide the link for relaying the probe data back to Earth. The total duration of the mission will be approximately four years.

The Galileo system will consist of an orbiter, a probe, and an upper stage adapter to accommodate integration of the Galileo system with the Centaur upper stage. The flight system will be powered by two general purpose heat-source radioisotope thermoelectric generators (RTG's) being developed by the Department of Energy. The orbiter will carry approximately 100 kg of scientific instruments and the probe will carry approximately 25 kg of scientific instruments.

During FY 1983, major activities on the Galileo program will involve completion of the orbiter subsystems and initiation of the orbiter spacecraft integration. In FY 1983, the probe will be intergrated and environmental testing will be accomplished, leading to integration with the orbiter in 1984.

The FY 1983 estimate reflects a reduction of $1.0 million. The change from a planned Inertial Upper Stage (IUS) launch in 1985 to a Centaur launch in 1986 made the development of a kick stage to accommodate the Galileo orbiter and probe launch on an Inertial Upper Stage no longer necessary. There is, however, the requirement to develop an adapter to permit the Galileo spacecraft to be intergrated with the Centaur.

The FY 1984 funding will provide for the integration of the Galileo orbiter and environmental testing of the entire system. Development of the ground systems required to support operation of the spacecraft will also be continued. In addition, the FY 1984 funding is required to reimburse the Department of Energy for the continued development of the radioisotope thermoelectric generators.

VENUS RADAR MAPPER MISSION

FISCAL YEAR 1984 FUNDING LEVEL

Spacecraft	$14,200,000
Experiments	11,600,000
Ground operations	3,200,000
Total	29,000,000

The Venus Radar Mapper (VRM) mission will be initiated in FY 1984. The mission objectives are to address fundamental questions regarding the origin and evolution of the planet Venus by obtaining global radar imagery of the planet. VRM will obtain altimetric and gravity data to determine accurately the gravity field, internal stresses, and density variations of the planet's interior. Detailed morphology of Venus will be analyzed to compare Venus' evolutionary history with the Earth's.

The VRM system will consist of a spacecraft and scientific instruments. The major scientific instrument will be a synthetic aperture radar which will be used to map the surface of Venus. The VRM is basically a scaled-down version of the Venus Orbiting Imaging Radar Mission to allow a viable planetary program to be continued within budgetary constraints. For example, the VRM will be developed by making maximum use of existing designs, technology, and residual hardware. The spacecraft system will rely heavily on previous Voyager experience. The synthetic aperture radar (SAR) will be based on existing designs.

The VRM spacecraft will be launched by the Space Shuttle/Centaur in 1988 on a direct trajectory to Venus, and inserted into a 3.7-hour near-polar elliptical orbit. The VRM will map essentially the entire planet in 243 days.

During FY 1983, extensive definition and preparation activities will be conducted on the VRM mission definition and planning as part of the Planetary Exploration advanced programs activities.

The current planning estimate for the VRM mission is in the $350 million range. This includes development through launch plus thirty days in-flight checkout, support during the 243-day mapping period, and analysis of the scientific data. The estimate for space transportation support is approximately $155–165 million.

FY 1984 funds will be used to initiate design and development activities on the Venus Radar Mapper Mission. Full-scale development contracts for the spacecraft system and the synthetic aperture radar (SAR) instrument will be awarded. A systems requirement review will be held early in the year to assure that mission objectives are properly translated into system requirements. All system-level designs will be completed, and the system preliminary design review will be held at the end of the year. Emphasis will be placed on determining and specifying the SAR imaging quality parameters and the altimetry performance requirements based on input from the VRM scientists. The spacecraft preliminary design will be completed, radio and power subsystem procurements will be initiated, and procurement action will be initiated on structural and thermal materials. For the SAR, the detailed circuit design will be completed, the test circuits assembled, and certain long-lead electronic components will be ordered. A design concept for the mission operations systems will also be established.

INTERNATIONAL SOLAR POLAR MISSION

FISCAL YEAR 1984 FUNDING LEVEL

Spacecraft	$3,000,000
Experiments	3,300,000
Ground operations	1,700,000
Total	8,000,000

The International Solar Polar Mission (ISPM) is a joint NASA and European Space Agency (ESA) program wherein ESA will provide the spacecraft and some instrumentation and NASA will provide the remainder of the instrumentation, investigator support, launch services, tracking, and radioactive thermal power generations. The mission is designed to obtain the first view of the solar system from outside the plane in which the planets orbit the Sun's equator. The mission will aid in the study of the relationship between the Sun and its magnetic field and particle emissions (solar wind and cosmic rays) as a function of solar latitude, thereby providing an insight into the effects of solar activity on the Earth's weather and climate. The ISPM will be launched in 1986 on the Shuttle/Centaur.

The ISPM was resructured in FY 1981, from a two-spacecraft mission—one provided by the United States and one provided by ESA—to a single ESA spacecraft mission; however, the United States participation in the program remains substantial. NASA is developing five of the nine principal investigator instruments and three of the four European investigations have U.S. co-investigators. In addition, the United States is providing two general purpose heat-source type radioisotope thermoelectric generators (RTG's); an adapter to accommodate the spacecraft integration with the Centaur; launch services; and tracking and data acquisition for the mission.

During FY 1983, the U.S. flight instruments will be delivered to the ESA spacecraft developer for integration and system testing. After the ISPM spacecraft system testing has been completed, the instruments will be calibrated before being stored in 1984 until launch. During FY 1983, the mission operations planning activities will be continued.

The reduction in the ISPM FY 1983 estimate is the result of the change from an Inertial Upper Stage (IUS) launch to a Centaur Upper Stage. With the Centaur, there is no requirement for the development of a kick stage to accommodate integration with the spacecraft as there was with an IUS launch. There is, however, the requirement to develop an adapter to permit the ISPM spacecraft to be integrated with the Centaur.

The FY 1984 funding is required to complete development of the U.S.-developed equipment required to adapt the ISPM spacecraft with the Centaur upper stage. In addition, principal investigator support will be continued.

Mission Operations and Data Analysis

FISCAL YEAR 1984 FUNDING LEVEL

Voyager extended mission	$19,100,000
Pioneer program	6,400,000
Planetary flight support	17,900,000
Total	43,400,000

The objectives of the mission operations and data analysis activities are in-flight operation of planetary spacecraft and the analysis of data from the missions. Currently two major classes of planetary spacecraft are operating—the Pioneer and the Voyager spacecraft. The planetary flight support activities are those associated with the design and development of planetary flight operation systems, and other activities that support the mission control, tracking, telemetry and command functions for all planetary spacecraft.

Voyager 1 is now on a cruise trajectory which will take it out of the solar system at a steep angle to the plane of the ecliptic, and it will continue to collect data on the space environment as it proceeds to the outer limits of the solar system. Voyager-2 is now on a course that will allow it to encounter the planet Uranus in 1986.

Operation of the Pioneer Venus and the Pioneer 6–11 spacecraft is continuing. The Pioneer Venus orbiter continues to collect data on the planet Venus which is scientifically important and is very significant in preparing for the Venus Radar Mapper mission. The Pioneer 6–9 spacecraft are operating in interplanetary space in solar orbit, and data is being acquired from the spacecraft when unusual solar phenomena occur or as unique scientific opportunities arise. The Pioneer 10 and 11 spacecraft are on a course that will take them out of the solar system in opposite directions.

Analysis of data from these missions continues to reveal profound scientific results. Analysis of the Voyager–1 data has led to the discovery of an oxygen-bearing molecule in the atmosphere of Saturn's satellite Titan, forcing a significant revision in the Titan photochemical models. Operation of the Mutch Memorial Station (Viking Lander–1) on Mars provided recent dust storm observations and other meteorological data.

The planetary flight support activities are those tasks related to the unique nature of planetary spacecraft flight operations, including design, development and operations of the planetary navigation system, the ground command and control system, the image processing system, and the ground data handling systems. In addition, the planetary flight support activities include the procurement, operation and maintenance of mission operations and general purpose scientific and engineering computing capabilities at the Jet Propulsion Laboratory.

During FY 1984, the operation and data analysis activities for the Voyager and Pioneer spacecraft will be continued. The FY 1984 planetary flight support funding will provide for the continued development of systems necessary for the Galileo and ISPM missions, as well as preparations for the Voyager–2 encounter with Uranus.

The increase of $12.0 million in the FY 1983 estimate is the result of Congressional appropriations above the FY 1983 NASA request. This additional funding will be used to keep the Pioneer spacecraft operational, and to enhance the Voyager data collection and flight support preparations for the Voyager Uranus encounter.

RESEARCH AND ANALYSIS

FISCAL YEAR 1984 FUNDING LEVEL

Supporting research and technology	$45,500,000
Advanced programs	11,300,000
Mars data analysis	1,500,000
Halley's comet co-investigations and watch	2,200,000
Total	60,500,000

The research and analysis program consists of four elements required to: assure that data and samples returned from flight missions are fully exploited; undertake complementary laboratory and theoretical efforts; define science rationale and develop required technology to undertake future planetary missions; and coordinate an International Halley's Comet Watch and provide co-investigator support to the European Space Ageny's Giotto mission to Halley's comet.

The supporting research and technology program element includes planetary astronomy, planetary geochemistry and geophysics, planetary atmospheres, planetary geology, planetary materials, and instrument definition.

The planetary astronomy activity includes all planetary observations made by ground-based telescopes. Observations are made at a wide range of wavelengths from ultraviolet to radio. The rate of new discoveries continues to be high. The data acquired is used both for basic research in support of planetary program objectives and for direct support of specific flight missions. The planetary astronomy funding in FY 1983 and FY 1984 provides for the continued operation of the Infrared Telescope Facility in Hawaii.

The planetary atmospheres activity includes data analysis, laboratory and theoretical efforts. The properties of other planetary atmospheres are amenable to measurement with planetary spacecraft and can aid us in a better understanding of our own weather and climate. Observations of the atmospheres of Venus, Jupiter and Saturn, acquired by Pioneer Venus and Voyager, have laid the basic observational groundwork for major advances in our knowledge about atmospheric sciences.

The planetary geochemistry and geophysics activity is broad in scope and includes studies of the composition and structure of all classes of solid body solar system objects. These investigations advance our understanding of the present state of the origin and evolution of the solar system. The program supports the synthesis of planetary data already obtained from previous missions, and the assembly of information needed to prepare for future missions. Both Voyager and Pioneer Venus continue to provide key data for these research efforts.

To date, the planetary geology activity has focused on studies of the surface properties of the inner planets (including the Moon). Voyager outer-planet data pertaining to the moons of Jupiter and

Saturn, primarily ice-covered bodies, have provided a new dimension for this effort. The geology program is a broadly based effort in which comparative studies of common processes affecting the development of surface features on bodies such as the inner planets provide a powerful technique for unravelling individual planetary histories. Imaging data, from both spacecraft and ground-based radar, provide the basis for much of the program.

The planetary materials activities support an active scientific effort to determine directly the chemistry, mineral composition, age, physical properties and other characteristics of solid material in the solar system through the study of returned lunar samples and meteorites. Extraterrestrial dust grains, collected for analysis, continue to yield new and otherwise unobtainable information about the solar system, particularly about its early history. The operation of the Lunar Curatorial Facility is also provided for within the planetary materials funding. This program is coordinated with the lunar sample and meteorite research supported by other agencies such as the National Science Foundation.

The instrument definition activity is directed toward ensuring that the science return from future missions is maximized through definition and development by the availability of state-of-the-art scientific instrumentation.

The objective of advanced programs is to provide planning and preparation for the systematic exploration of the solar system on a scientifically and technically sound basis. Prospective planetary missions are identified and defined through long-range studies; their technological and fiscal feasibility is evaluated, and their scientific merit is determined through interaction with the scientific community. The strategy for future solar system exploration has been studied by the Solar System Exploration Committee (SSEC), an advisory group, which has recommended several "low-cost" but scientifically important potential future missions.

The Mars Data Analysis efforts continue to assure that we capitalize on the wealth of data provided by Viking and earlier missions. This activity covers a broad scope of the analysis and synthesis of returned data related to the disciplines of biology, chemistry, geology, and meteorology.

The International Halley's Comet Co-Investigations and Watch will capitalize on the opportunity to observe Comet Halley during its next apparition in 1985–1986 by supporting co-investigators on the European Space Agency (ESA) Giotto mission, and by conducting complementary remote sensing investigations using both Earth-orbiting and ground-based facilities. The ESA Giotto mission will fly by Halley's Comet in 1986. Concurrently, an observation program called the International Halley's Comet Watch, coordinated by the United States, will conduct world-wide scientific observations of the Comet Halley. The objectives of the Watch are to: (1) coordinate scientific observations of Comet Halley throughout its 1985–1986 apparition; (2) promote the use of standardized instrumentation and observing techniques; (3) help insure that data are properly documented and archived; and (4) receive and distribute data to participating scientists.

The increase of $14.8 million in the FY 1983 estimate is the result of Congressional appropriations over the FY 1983 budget request. These funds will be used to continue operation of both the Infrared Telescope Facility in Hawaii, and the Lunar Curatorial Facility at the Johnson Space Center. In addition, the university research program will be enhanced, the Mars data analysis activities will be continued, and the international Halley's Comet watch activities will be enhanced.

During FY 1984, research efforts will continue in the areas of planetary astronomy, planetary atmospheres, planetary geochemistry and geophysics, planetary geology, planetary materials, instrument definition, Mars data analysis, and development of required technology to undertake future missions. Telescope observations will provide data complementary to that obtained from the flight missions, with emphasis on the outermost planets, comets and asteroids. A variety of efforts will be pursued to improve our understanding of planetary atmospheres, including laboratory studies of reactions in deep planetery atmospheres and in tenuous cometary atmospheres. In the geochemistry-geophysics area, research efforts will be carried out to better understand the present state of evolution of individual bodies and of the solar system in general. Geology research will be directed at specific problems in understanding the various processes that have shaped planetary surfaces, as well as geological analyses and a cartography effort based on the Galilean satellite imaging data acquired by Voyager. Analysis of lunar samples, meteorites, and extraterrestrial dust particles will be continued in FY 1984 to determine their chemical and physical properties and thereby derive their origin and evolutionary history. Instrument definition for potential future missions will also be continued.

The FY 1984 Halley's Comet Co-Investigations and Watch funding is required to support U.S. coinvestigators involved in the European Space Agency's Giotto mission. It is also required to provide support for a Jet Propulsion Laboratory management team who, together with several scientists at other institutions, are establishing a worldwide network for the astronomical study of Halley's Comet in 1985-1986.

5. LIFE SCIENCES PROGRAM, $59,000,000

FISCAL YEAR 1984 FUNDING LEVEL

Life science flight experiments	$23,000,000
Research and analysis	36,000,000
Total	59,000,000

The goals of the Life Sciences program are to provide a sound scientific, medical, and technical basis for safe and effective manned space flight, and to advance the understanding of the basic mechanisms of biological processes by using the unique capabilities of the space program. Results from the research program are applied to: the immediate needs in the maintenance and health of the astronauts; understanding the response of biological systems to weightlessness; the design of advanced life support systems for use on future missions; and understanding the biosphere of the planet Earth, its origin, evolution, and present estate.

The Life Sciences program is a key developing a capability to sustain a permanent manned presence in space and utilizing the space environment to study living systems. These efforts include both ground-based and space research efforts which are mutually supportive and integrated, and use a composite of disciplines and techniques in both biology and medicine to address space-related medical problems and fundamental biological processes.

The Life Sciences research and analysis program includes several major elements: operational medicine which is focused on the health and well being of Space Shuttle crews; biomedical research which is directed toward understanding the preventing any adverse physiological changes which occur in space flight; advanced life support systems, which is a program of research and technology development for life support systems necessary to maintain life in space autonomously for long periods of time; space biology which consists of flight and ground-based experiments that focus on using microgravity as a biological research tool to understand its effect on plants and animals; exobiology research which is directed toward understanding the origin and distribution of life and life-related molecules on Earch and throughout the universe; and global biology research which is directed toward understanding the interaction between life on Earch and its physical and chemical environment.

The goals of the Operational Medicine and Biomedical Research programs are to assume astronaut and payload specialist health and ability to function effectively in the space environment. Eventually, experience gained from the medical operations support to space flight will allow a broader segment of the population to participate in all aspects of future space missions. Particular emphasis is being placed on testing countermeasures designed to prevent physiological problems associated with exposure to the space environment. It is essential that long-term monitoring of spaceflight crews be performed in a standardized and organized fashion in order to develop risk factors and establish the long-term clinical significance associated with repeated exposure to the space enviroment. In addition, biomedical research is designed to understand the physiological basis for problems encountered in manned space flight. Areas of emphasis include: vestibular dysfunction, behavioral changes, cardiovascular deconditioning, bone and muscle loss, and radiation damage. This research concentrates on trying to define potential flight experiments and countermeasures for use during spaceflight.

The Advanced Life Support system program supports activities ranging from the development of less constraining and more efficient space suits and life support systems for the astronauts, to scientific work in chemistry and biology necessary to understand how life can be maintained in systems which receive only energy from the external environment. All are aimed at potential future needs of long duration manned space flight.

The objective of Space Biology activities is to further our understanding of basic physiological mechanisms through the use of microgravity and the space environment. Plant and animal experiments have been flown on three Soviet Cosmos satellites and on the Shuttle orbital flight tests; experiments are under development for all Shuttle flights up through the Spacelab 4 mission. These experiments will explore the physiological effects of space flight on inner ear function, blood factors, bone formation, and plant growth and structure. The information obtained should contribute to the solution of biological and medical problems on Earth as well as contribute to man's effective functioning in space. The unique properties of space (e.g., microgravity) provide and opportunity to explore significant problems in biology under controlled conditions that cannot be duplicated in laboratories on Earth.

The Exobiology efforts are concentrated on studies of life's origin, with particular emphasis on developing sound hypotheses which could lead to discovering the relationships which may link the beginnings of life to the formation of the solar system and the Earth itself. Ground-based research on model systems and analysis of extraterrestrial materials, coupled with the results of flight experiments, are clarifying the mechanisms and environments conducive to the formation of essential biomolecules.

Studies of life's origin and evolution must be extended to enhance our understanding of the interaction of the biota with the Earth's present environment, and thereby provide a more comprehensive picture of life—its past, present, and future.

LIFE SCIENCES FLIGHT EXPERIMENTS

FISCAL YEAR 1984 FUNDING LEVEL

Life sciences flight experiments	$23,000,000

The objective of the Life Sciences Flight Experiments program is to assimilate information and questions from the various life sciences disciplines and translate them into payloads designed to expand our understanding of the basic physiological mechanisms involved in adaptation to weightlessness. The program includes selection, definition, inflight execution, data analysis, and reporting of medical and biological investigations. Past experience indicates that humans clearly undergo physiological changes in weightlessness. Thus far these changes appear to be reversible upon return to Earth: however, many of the observed changes are physiologically significant and are not well understood. With weightless exposure beyond several months, these changes may prove irreversible. Early Shuttle-Spacelab missions are suitable for gaining a greater understanding of the early physiological response to weightlessness, which will improve the management of several existing problems (e.g., space motion sickness) and will enhance the confidence of estimating the physiological consequences of more sustained weightless exposure.

Current activities involve the development of life sciences flight experiments to be flown on Spacelab-1 and 2, and the German-D1 mission (Spacelab-D1). Most of the experiments on board the early Shuttle flights will serve as pathfinding activities for Spacelab-4, the first Spacelab mission dedicated entirely to life sciences investigations. Hardware and experimental protocols for flights through Spacelab-2 are well developed. Activities on Spacelab-3 will involve evaluation of functional performance and biocompatibility of hardware that is essential to human and animal investigations which will be conducted on Spacelab-4. Hardware development and mission planning activities are proceeding on schedule for the United

States vestibular experiment which will be flown on the German-D1 (Spacelab-D1) mission.

Twenty-five investigations have been tentatively selected as the scientific payload for Spacelab-4. The definition phase activities have been completed leading to final payload selection, and initiation of design and development of the flight hardware has begun. These investigations have been combined into a comprehensive, integrated exploration of the known problems of manned space flight through the use of both human and animal subjects. Teams of principal investigators will examine cardiovascular adaptation, space motion sickness, muscle wasting, demineralization of bone, and the early anemia of weightlessness. This mission will be unique in several respects: it will be the first Shuttle/Spacelab mission dedicated entirely to life sciences; it will involve highly skilled scientists as payload specialists, permitting the use of numerous experimental techniques and procedures never before utilized in space; and the experiments will employ complementary human and animal investigations in order to validate models for human physiology.

FY 1984 funding is required for the continuing definition and development of hardware which will be flown on future Spacelab missions, i.e., Spacelab-3, D1, and 4. Flight hardware integration and experiment development associated with Spacelab-2, 3, and D1 will be completed in preparation for launches in 1984 and 1985. Final experiment selection of investigations for the first life sciences dedicated mission (Spacelab-4) will be completed and experiment design and development of associated hardware will be initiated. In addition, the selection process for experiments for the follow-on dedicated Spacelab life sciences mission will be initiated.

LIFE SCIENCES RESEARCH AND ANALYSIS

FISCAL YEAR 1984 FUNDING LEVEL

Life sciences research and analysis	$36,000,000

The research and analysis activity of the Life Sciences program is concerned, in part, with ground-based research in biological and medical problem areas that have been identified in previous manned flights. The program is comprised of six elments: (1) operational medicine; (2) biomedical research; (3) advanced life support systems research; (4) space biology; (5) exobiology; and (6) global biology.

The Life Sciences Operational Medicine program is responsible for bringing the science, technology, and practice of medicine to bear on solving the problems of sustaining, supporting, and protecting individuals working in the space environment. This includes assuring physical welfare, performance, and adequate treatment of in-flight illnesses or injuries. Such manifestations as space disorientation, fluid shifts, and endocrine shifts, which can cause decreased performance in flight, as well as decreased cardiovascular tolerance and possible aggravation of latent diseases, will be carefully documented with the goal of future prevention or mitigation to the extent possible. To this end, specific operational requirements such as careful medical selection, periodic evaluation of health status (including pre- and post-flight medical observation), and in-flight monitoring of the time course of adaptation and performance in the space environment will be continually reevaluated and updated.

The Biomedical Research program seeks to develop the basic medical knowledge needed to enable men and women to operate more effectively in space. The program is organized into discrete elements, each designed to rectify a particular physiological problem known or expected to affect the human organism in space. Such problems as motion sickness, bone loss, and electrolyte imbalances are under intense scrutiny not only to provide a better understanding of their underlying causes, but also to develop more effective preventive measures. The program makes extensive use of ground-based simulation techniques which evoke, in both humans and animals, physiological changes similar to those seen in space.

The Advanced Life Support Systems research program concentrates on enhancing our ability to support long-duration manned presence in space and on optimizing the productivity of mixed spacecraft crews. Improvements are sought in space craft habitability and man-machine system engineering methods as well as a means to provide air, water, and food to support life directly. The program has developed technology for building apparatus to regenerate spacecraft air and water supplies in flight and in investigating the scientific basis to regenerate spacecraft air and water supplies in flight and is investigating the scientific basis for new systems such as food recycling for long-term missions. Research is in progress on space suits for quick reaction situations and on innovative approaches to designing space tools and work stations.

The Space Biology program explores the role of gravity in life processes and uses gravity as an environmental tool to investigate fundamental biological questions. Specific objectives are to: (1) investigate and identify the role of gravity in plant and animal behavior, morphology and physiology; (2) identify the mechanisms of gravity sensing and transmission of gravity perception information within both plants and animals; (3) identify the interactive effects of gravity and other stimuli (e.g., light) and stresses (e.g., vibration and disorientation) on the development and metabolism of organisms; (4) use gravity to study the normal nature and properties of living organisms; and (5) extend the limits of knowledge about plant and animal growth as well as long-term survival and multigeneration reproduction of life in space. The program provides important ground-based information needed to develop future space flight experiments and life support systems.

The exobiology program is directed toward furthering our understanding of the origin and evolution of life and life-related molecules, on Earth and elsewhere in the universe. Research, in general, builds on data acquired by missions in planetary exploration and astrophysics to uncover the relationship between the origin and evolution of the solar system and life itself. Theoretical and laboratory investigations are also included in this program to develop a better understanding of the conditions on the primitive Earth as related to early chemical and biological evolution.

The Global Biology program explores the interaction between the biota and contemporary environment to develop an understanding of global bio-geochemical cycles. Laboratory and field investigations are correlated with remote sensing data to characterize the influence of biological processes on global dynamics. Biospheric modelling efforts focus on integrating biology with atmospheric, climate, oceanic, terrestrial, land bio-geochemical cycling data to reflect the state of the biosphere as a function of both natural and anthropogenic perturabations.

In FY 1984, the Operational Medicine program will, investigate and collect information on occupational exposures in zero-gravity on each Shuttle flight; conduct inflight clinical testing of countermeasures especially in the areas of cardiovascular deconditioning and vestibular problems, and develop health care procedures compatible with the space environment. Annual and pre- and postflight medical data will be collected in order to better define responses of different population groups to space flight.

In FY 1984, the Biomedical Research program will focus primarily on problems related to vestibular dysfunction because of their relevance to Shuttle operations. Psychology, human factors, and the enhancement of performance are all receiving increased emphasis. Studies of bone loss and of electrolyte imbalance will also be pursued so that potential countermeasures can be devised. Increased awareness and understand of a potential radiation hazard from space flight has resulted in more emphasis being placed on the precise measurement of radiation doses, the specific bioligical effects of cosmic rays, and the identification of possible radiation shielding.

In FY 1984, the Advanced Life Support Systems program will continue to investigate basic biological processes and physical/chemical methods which will provide capabilities to recycle air, water, food and wastes; and continue definition of concepts for improved space suits and portable life support systems.

In FY 1984, the Space Biology program will focus on continuation of research directed at understanding animal and plant equilibrium, gravity perception, and biotransduction mechanisms, as well as gravity's effect on plant and animal development, structure, and behavior. Increased emphasis will be placed on research that will lead to the Development of hypotheses, and provide baseline data for future Shuttle/Spacelab flight experiments.

In FY 1984, the Exobiology program emphasis will be placed on the continuation of such efforts as expanding our knowledge of non-biological mechanisms of synthesis of biologically significant molecules both in space and on the Earth. This research is crucial for gaining further insight into the origin of life as well as assessing the possibility of these processes occurring elsewhere in the universe.

In FY 1984, the Global Biology research program will place emphasis on improving our estimating techniques for determining the size and distribution of the terrestrial biomass by combining ground-based measurements with remote sensing data. Additional emphasis will be placed on characterizing biogenic gas fluxes of key atmospheric constituents. This information is required for development of a better understanding of global bio-geochemical cycles.

In FY 1984, emphasis will also be placed on the formulation of improved approaches to the operational management of space adaptation. Based on current research, in-flight evaluation of these concepts will be and in-flight evaluation of biofeedback and drug therapy techniques are presently under definition. A middeck rotator will be used on the Shuttle as part of a series of studies which will investigate the inflight effectiveness of various countermeasures. Definition of compatible ground and flight research theories and proposed techniques is planned.

6. SPACE APPLICATIONS, $306,000,000

FISCAL YEAR 1984 FUNDING LEVEL

Solid Earth observations program	$83,400,000
Environmental observations program	166,000,000
Materials processing in space program	26,600,000
Communications program	21,100,000
Information systems program	8,900,000
Total	306,000,000

SOLID EARTH OBSERVATIONS PROGRAM

FISCAL YEAR 1984 FUNDING LEVEL

Landsat-4	$15,800,000
Extended mission operations	1,000,000
Shuttle/Space payloads	15,000,000
Geodynamics	28,000,000
AgRISTARS	2,000,000
Research and analysis	18,600,000
Technology transfer	3,000,000
Total	83,400,000

The objectives of the Solid Earth Observations program are to develop and apply space observation techniques to meet national and global needs for improved management of food, fiber, water and land resources; to improve our ability to systematically evaluate the composition and geometry of the Earth's mineral and energy resources; and to increase our understanding of the Earth, its interior structure and composition, its rotational dynamics, the processes related to the movement and deformation of its crust, and mechanisms associated with the occurrence of earthquakes.

Principal elements of the program include the development of space and supporting ground systems and improved data processing and analysis techniques; Shuttle and aircraft support for sensor and technique development; as well as basic and applied research for identifying, monitoring, analyzing and modeling the vegetated and geological features of the Earth.

Another aspect of the Solid Earth Observations program is the research associated with understanding the physical relationship of sensed phenomena to various types of vegetation and other surface features with the radiation which they emit or reflect; the development of models appropriate to the management of resources; and the evaluation of the use of space-derived data along with other data sources in meeting user needs. These activities include individual scientific studies and projects, such as the Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS).

Studies of the movement and deformation of the Earth's crust, the rotational dynamics of the Earth, and the Earth's gravity and magnetic fields provide information which is needed to: understand the processes leading to the release of crustal strain in the form of earthquakes; improve our understanding of the formation of mineral deposits; contribute to long-term weather and climate forecasting; and better understand the Earth as a planet. Space techniques such as laser ranging to satellites and the Moon, and very long baseline interferometry using radio stars or satellites, are the only methods which can provide the precise measurements needed for these studies.

Landsat-4 was launched in July 1982 and both the flight and ground systems are performing well. Data from the two key instruments, the Thematic Mapper (TM) and the Multispectral Scanner (MSS), are proving to be very useful to the science and applications community. The TM data received and processed to date is of excellent quality and holds promise for many new applications in civil remote sensing. NOAA will assume operational responsibility in 1983 for the spacecraft and MSS instrument, while NASA will operate and conduct research with the TM experiment until 1985. Development of the Landsat-4 backup spacecraft, Landsat-D prime, will be completed in 1983 and turned over to NOAA for storage.

The objective of the Shuttle/Spacelab payload development project is to develop, test, and evaluate Earthviewing remote sensing instruments and systems to obtain data for solid earth observations research. Both the Shuttle Imaging Radar, which was flown on the Shuttle orbital test flight in November 1981 to evaluate the utility of spaceborne imaging radar for geologic exploration, and the Shuttle Multispectral Infrared Radiometer, which was used to determine the optimum spectral bands for surface materials classifications, operated successfully. The Large Format Camera, required for high resolution mapping applications, is being prepared for launch on the Shuttle in 1984. The next generation Shuttle Imaging Radar is under development leading to a 1984 Shuttle launch.

The focus of the Multispectral Linear Array (MLA) advanced technology development is on the development of a future high performance MLA instrument which can be used as a diagnostic tool for fundamental research in remote sensing. The MLA solid-state sensor has a number of significant features such as electronic scan, inherent geometric and spectral registration, and programmable high spatial and spectral resolution. The critical technology development and supporting research on the linear array instrument and the Shuttle Imaging Spectrometer is being continued in FY 1983.

Landsat-4

The objective of the Landsat-4 program is to develop, launch, and operate an advanced land observing system and to assess and demonstrate the utility of satellite-based Earth resources remote sensing systems with the new experimental Thematic Mapper (TM) and the flight-proven Multispectral Scanner (MSS). Landsat-4 was launched successfully in July 1982. The Landsat-4 backup spacecraft (Landsat-D prime) will be available for launch in 1983. The major technical focus of the Landsat-4 program involves a test of the Thematic Mapper's capabilities and an improved ground data handling system. The Thematic Mapper will offer higher resolving power and greater spectral coverage than existing instruments. These advantages promise to open up a significant number of new uses of Landsat data and enhance many current uses.

While the National Oceanic and Atmospheric Administration (NOAA) will assume control of Landsat-4 operations in early 1983, NASA will maintain operation of the TM and associated systems. The completion of Landsat-D prime is scheduled for 1983; NOAA will store the spacecraft until it is required for launch.

The Thematic Mapper (TM) processing system is nearing completion. At the time of the Landsat-4 launch, the TM research and development data production rate approximately one scene per day. During the first year of operation, the sensor performance is being characterized and the necessary software is being developed to permit a production rate of 12 scenes/day by mid-1983, rising to 50 scenes a day upon turnover of the TM system to NOAA for routine operations.

FY 1984 funds will be used to operate the Landsat TM data processing ground systems, and the complete NASA's engineering characterization of the TM data.

Extended Mission Operations

The objective of extended mission operations is to capitalize on the continued performance of Solid Earth Observations program satellites beyond the initial planned mission duration. Data products from these missions are being used to support research and operational activities in agriculture, water resources, geology, and land use. In the case of Landsat, some operational requirements of federal and state agencies, plus many private interests are now being satisfied.

Landsat-3 is currently operating and providing data, although at reduced operational levels. Completion of Magsat data analysis will be accomplished in 1983.

The FY 1984 funding is required to support the analysis of data as it applies to agricultural, forestry, water, and land management studies, Landsat-3 will be maintained in a standby operational mode through FY 1984.

Shuttle/Spacelab Payload Development

The objective of this project is to develop, test, and evaluate Earth-viewing remote sensing instruments and systems to obtain data for land remote sensing research.

In FY 1983, preparations are continuing for the flights of the Large Format Camera (LFC) and the Shuttle Imaging Radar-B (SIR-B). The Large Format Camera is required for high resolution mapping applications. The new attitude reference system for the LFC has been completed, and the launch of the LFC is scheduled for 1984. The SIR-B will obtain a quantitative assessment of the effect of various radar viewing geometries on the mapping of surface texture and topographic features. The SIR-B instrumentation is based on an upgraded SIR-A instrument including the addition of a variable look angle antenna, digital data handling, and increased bandwidth and resolution. Data will be recorded on board and transmitted via the Tracking and Data Relay Satellite System (TDRSS).

The focus of the Multispectral Linear Array (MLA) technology development is on a future high performance MLA instrument for use as a diagnostic tool on the Space Shuttle for fundamental research in remote sensing. The MLA class of solid state sensors has a number of significant features, such as electronic scan, inherent geometric and spectral registration, and programmable high spatial and spectral resolution. The MLA will be flown and tested on a future Shuttle/Spacelab mission.

FY 1984 funding is required for experiment operations and data analysis for two flights of the Large Format Camera and the first flight of the Shuttle Imaging Radar-B (SIR-B). FY 1984 funding is also required for continued definition of a Multispectral Linear Array Shuttle mission concept and development of an MLA experimental instrument.

Geodynamics

The Geodynamics program makes use of the unique capabilities provided by space techniques to improve our understanding of the dynamic processes occurring within the Earth and at its surface. The objectives of the program are to: contribute to studies of earthquake mechanisms by measuring and modeling crustal deformation at active plate boundaries; verify and extend tectonophysical theories by measuring the contemporary motions of the plates and determining the plate-driving forces; study causative relationships between variations in the Earth's polar motion and rotational rate with earthquake occurrence, internal core dynamics, and other physical phenomena; model geophysical processes associated with the formation of petroleum and mineral deposits; study mantle convection and the internal composition and structure of the Earth; and facilitate the establishment of new geodynamic measurement services which will make use of precise position determination methods.

The principal activity under the Geodynamics program is the crustal dynamics project. This project supports the development of laser ranging and very long baseline interferometry systems for measurement of plate motion, plate stability, regional crustal deformation, polar motion, and Earth rotation. The data obtained is expected to contribute to the understanding of why and how earthquakes occur and, perhaps, to the development of earthquake prediction methods. Project activity is conducted jointly with the National Oceanic and Atmospheric Administration, the U.S. Geological Survey, the National Science Foundation, and the Defense Mapping Agency, through an interagency agreement for the application of space technology to crustal dynamics and earthquake research. The laser network supports the project through the acquisition and processing of laser data for sites in the United States, the Pacific, South America, and Australia.

A principal focus of the crustal dynamics measurements has been the study of the relative motion of the North American and Pacific plates at their boundary along the San Andreas fault system in California, and of how and where crustal strain is accumulating in this area. In 1982 an agreement was concluded with

Mexico for a U.S. laser ranging site at Mazatlan. With this new location, it will now be possible to study the continuation of the San Andreas fault in to the Gulf of California, and the spreading of Baja California northward away from the mainland. In 1984, measurements of crustal deformation in the western United States and northern Mexico will be continued, and will be extended into Canada; measurements in Alaska will be started. Since major earthquakes are infrequent in the United States, NASA is cooperating with a consortium of European countries in studies of regional crustal deformation in the eastern Mediterranean. These studies will begin in 1984 through the use of U.S. systems and systems developed by the Europeans.

To date, measurements of present plate motion have been limited to the Pacific, Australian, North American, and Eurasian plates. In 1982, agreements were concluded with France for a laser ranging site in the Society Islands, and with Chile for a laser site on Easter Island. In addition, the Japanese have procured a laser from a U.S. source and, based on an earlier agreement with NASA, are developing a microwave interferometry system. In 1983, the Easter Island laser will be used to start measurement of the movement of the Nazca plate relative to the South American plate, and in 1984 extensive studies of the movement and internal deformation of the Pacific plate will be studied using sites in Japan, Alaska, Hawaii, the Society Islands, and Australia.

Development is continuing on a geodetic receiver design (SERIES), which uses signals from the Global Positioning System. The mobile laser stations (MOBLAS) have been upgraded to two-centimeter ranging, and two highly mobile transportable laser stations (TLRS) have been completed and deployed. An interagency plan has been initiated to establish the national crustal motion network by NOAA in 1984 with NASA assistance, to operate a polar motion monitoring network (POLARIS) by NOAA, and to establish local crustal strain monitoring networks by U.S. Geological Survey through the use of Global Positioning System receivers. The feasibility of using satellite-to-satellite tracking to substantially improve gravity field surveys was demonstrated in the laboratory. Conceptual studies of the Geopotenial Research Mission, aimed at making the next major advance in gravity and magnetic field measurement, have been completed.

In FY 1984, the western United States regional deformation measurements and measurements of the relative motion of the North American and Pacific plates will be continued. Analysis of these data and earlier data will provide maps of large-scale crustal deformation in the western United States. Alaska regional measurements will be initiated. Operation of the laser network will be continued. Theoretical modeling studies of crustal motion and internal core dynamics, and modeling and interpretation of geopotential fields will be continued. System definition studies for the Geopotential Research Mission will be conducted.

Agristars

AgRISTARS is a research, development and test program, which addresses Department of Agriculture (USDA) information requirements by combining NASA's unique remote sensing research and development with complementary resources from the USDA and Department of Commerce. Improved imformation on world agricultural production has been identified by the USDA as a major information requirement for extablishing effective United States agricultural policies, and for efficient operation of United States agricultural markets. With present resource limitations and political situations in many countries, aerospace remote sensing provides the only feasible means for making reliable foreign production forecasts.

This program has become the focal point of remote sensing research for application to global vegetation assessments, both within the involved federal agencies and by the scientific community in general. In addition to commodity production forecasting improvement, USDA information requirements are in the areas of resource management, land-use monitoring, and the remote measurement of soil moisture.

Research and Analysis (Solid Earth Observations)

The goals of the research and analysis activities are: to improve our understanding of the remote sensing process; to develop remote sensing techniques that aid in the management of renewable and nonrenewable resources, to monitor the impact of man on the natural environment, and to perform feasibility studies required prior to initiation of new space flight sensor development and mission definition. This program incorporates the field experiments with aircraft and satellite-based data analysis for renewable and nonrenewable solid Earth observations research, and associated feasibility and conceptual design studies of future sensors, Shuttle experiments, and space missions.

In fundamental research, a coordinated set of theoretical and experimental investigations is being continued in scene radiation, atmospheric effects characterization, mathematical pattern recognition, and image analysis. This research extends and strengthens our basic understanding and provides the generic remote sensing science required for technique development in the renewable and nonrenewable resource discipline sciences.

In renewable resources, the focus is on evaluating the improved capability of the Landsat-4 Thematic Mapper over the Multispectral Scanner to inventory and determine contributing sensor parameters and to monitor land cover. The Thematic Mapper data analysis has confirmed our findings from simulator research regarding increased dimensions of the data over Multispectral Scanner and a continuing as well as increased level of information. Multisensor and multispectral research in being conducted to extend this technique from the visible infrared to the microwave regime in a synergistic way.

The objectives of the nonrenewable resources effort are to: develop techniques for extracting useful geological information from remote sensing measurements; employ remote sensing techniques in unique and innovative ways for studies of crustal geology; develop improved geological models which can make effective use of unique types of information derived from space-acquired data; and experimentally evaluate the utility of remote sensing methods for specific geological applications. Emphasis has been placed on the use of thermal infrared and microwave remote sensing techniques. Development of an infrared aircraft scanner was completed and flown during 1982 to collect six-channel multispectral data in the 8–13 micron spectral region over a series of western United States test sites. In addition, intensive analysis and interpretation of the radar imaging data obtained during the second Shuttle orbital test flight is being continued in FY 1983.

In the advanced studies area, feasibility and conceptual design studies of future sensors and missions are being conducted to ensure the conceptualization of high priority future capabilities in remote sensing of Earth resources.

During FY 1984, the research and analysis disciplines will make use of the data from the infusion of Landsat-4 Thematic Mapper data. New radar data from the SIR-B will also become available. The FY 1984 Research and Analysis program will focus on the analysis of these new data and technique development will be continued with emphasis on merging multisensor/multispectral data sets. Advanced mission studies will be continued with emphasis on Shuttle-borne sensor feasibility studies and space station payload studies.

Technology Transfer

The technology transfer provides for the development, experimental test and evaluation, and transfer of remote sensing technology applications for operational use by public and private organizations.

User requirements and supporting activities have maintained communications at the national level between NASA and the user community to determine and analyze national priorities and user needs, inform users of existing and planned technological capabilities, otain external evaluations of technology transfer programs for planning purposes, and develop program awareness and technical capabilities in educational institutions. Cooperative efforts have been conducted with state and local governments to evaluate proven Landsat applications in natural resource and environmental management.

Fiscal year 1984 funding will be used to continue these important activities which encourage the transfer of remote sensing technology to public and private organizations.

ENVIRONMENTAL OBSERVATIONS PROGRAM

FISCAL YEAR 1984 FUNDING LEVEL

Upper atmosphere research and analysis	$29,600,000
Atmospheric dynamics and radiation research and analysis	28,400,000
Oceanic processes research and analysis	18,200,000
Space physics/ATD research and analysis	18,700,000
Shuttle/Spacelab payload development	7,600,000
Operational satellite improvement program	600,000
Earth radiation budget experiment	15,500,000
Extended mission operations	27,400,000
Upper atmosphere research satellite experiments and mission definition	20,000,000
Total	166,000 000

The objectives of the Environmental Observations program are to improve our understanding of the processes in the atmosphere and the oceans, provide space observation of parameters involved in these processes, and extend the national capabilities to predict environmental phenomena, both short and long term, and their interaction with human activities. Because many of these phenomena are global or regional, they can be most effectively, and sometimes solely, observed from space. NASA's programs include scientific research efforts plus the development of new technology for global and synoptic measurements. NASA's research satellites provide a unique view of the radiative, chemical and dynamic processes occurring in the atmosphere and oceans.

To achieve these goals, a number of significant objectives have been established for the next decade. These include advancing the understanding of the upper atmosphere through the determination of the spatial and temporal distribution of ozone and select nitrogen, hydrogen, and chlorine species in the upper atomsphere and their sources in the lower atmosphere; optimization of the use of space-derived measurements in understanding large scale weather patterns; advances in our knowledge of severe storms and forecasting capabilities; ocean productivity and air-sea interactions; and an improved knowledge of seasonal climate variability leading to a long-term strategy for climate observation and prediction and a comprehensive understanding of the solar terrestrial connection and detailed determination of the physics and coupling between the solar wind, magnetosphere, and ionosphere.

Effective utilization of remote sensing requires a balanced set of activities including: analytical modeling and simulation, laboratory research of fundamental processes, development of instrumentation, flight of the instruments on the Space Shuttle and dedicated spacecraft, collection of *in situ* ancillary or validation data, and scientific analysis of data. The approach is to develop a technological capability and a strong scientific base and then to collect appropriate data (from space and *in situ*) which, taken together, will address a particular program objective.

Studies of the upper atmosphere have lead to a new assessment of the impact of chlorofluorocarbons on stratospheric ozone which was reported to the Congress in January 1982. The revised assessment of the predicted impact is somewhat less severe; this assessment is the result of improved measurements in our continuing program of laboratory chemical kinetics measurements.

Three-dimensional models of the stratosphere are being developed to quantify our understanding of the interrelation of chemistry with dynamics and radiation. The record of satellite ozone measurements now extends for over a decade and is being used in studies to determine if there have been long term trends in the average amount of global ozone which shields the Earth's surface from harmful ultraviolet radiation.

The Upper Atmospheric Research Satellite Experiments (UARSE) development effort which was initiated in FY 1982 will provide a set of satellite instruments capable of making a comprehensive measurement of the state of the stratosphere. Detailed definition studies of sixteen instruments have been completed, and an instrument complement has been selected. Further definition of the UARS mission will be undertaken to try to decrease the cost of the mission below the current estimate.

The Earth Radiation Budget Experiment (ERBE) development is proceeding on schedule toward a 1984 launch date. NASA is also continuing to support the National Oceanic and Atmospheric Administration (NOAA) by managing the implementation of the NOAA and Geostationary Operational Environmental Satellites (GOES) series on a reimbursable basis. Preparations are proceeding to launch NOAA-E and GOES-F in 1983, and NOAA-F in 1984.

The ability to perform temperature and moisture soundings of the atmosphere from geostationary orbit has been demonstrated by the flight of the NASA-developed visible/infrared spin-scan radiometer and atmospheric sounder instrument on GOES-4 and NOAA-5 spacecraft. The opportunity afforded by geostationary orbits to observe a localized region continuously will permit intensive study of the evolving temperature and moisture environment of severe local storms. Low Earth orbit sounding capabilities are now enabling the extension of forecast reliability from three to five days. In certain situations, reliable forecasts of 8 to 10 days duration have been achieved.

Virtually all of the data from the Seasat mission has been archived and much of the Nimbus-7 ocean data has been analyzed. This information is being used to define potential low cost approaches to use demonstrated ocean observing techniques to address a variety of ocean research challenges.

The Nimbus spacecraft continue to collect unique data sets to aid in the study of long term trends of the Earth's atmosphere, oceans and polar ice. The Solar Mesosphere Explorer (SME) data collection over the last year has made a major contribution to the study of the El Chichon volcano. In addition, the ISEE-3 spacecraft will be prepared for the planned encounter with the comet Giacobini-zinner in 1985.

Upper Atmospheric Research

The upper atmospheric research program is a comprehensive research and technology effort designed to investigate and monitor the phenomena of the upper atmosphere. It is aimed at improving our basic scientific understanding of the global atmosphere and the methods needed to assess its susceptibility to significant chemical and physical change.

In particular, the goal of the upper atmospheric research program is to understand the physics, chemistry and transport processes in the atmoshpere on a global scale, and to assess as accurately as possible the perturbations to the atmosphere caused by man's activities. In order to accomplish this, efforts are underway to: (1) improve upper atmosphere and global troposphere models, validate them, and assess their uncertainties; (2) measure important trace chemical constituents, temperature, and radiation fields throughout the atmosphere; (3) develop sensors capable of making chemical and physical measurements of the upper atmosphere and the global troposphere in situ and remotely from space; (4) assemble and maintain the existing long-term data base of stratospheric and tropospheric ozone measurements to aid in the detection of long-timescale natural variations and man-made ozone changes; (5) determine the effects of global tropospheric chemistry on the atmosphere as a whole in order to assess the role of the global troposphere as the source and sink of stratospheric species; and (6) conduct theoretical and field studies of tropospheric/stratospheric exchange; and (7) carry out laboratory kinetics and spectroscopy to support these activities.

A wide variety of in situ and remote sensing instruments needed to meet the objectives of determining and understanding the distribution of ozone and key nitrogen, hydrogen, and chlorine radical and molecular species in the atmosphere have been developed and utilized. These measurements have been made from the ground as well as from aircraft, balloons, rockets, and spacecraft. A number of advanced measurement systems are being developed and will be test-flown on the Shuttle in order to explore the unique Shuttle capabilities for environmental sensing. With the recent availability of processed data from the Stratopheric Aerosal Gas Experiment (SAGE), Nimbus-4, -6, -7, and the Defense Meteorological Satellite, a major effort is underway to extract the maximum understanding from this data. An Applications Notice has been released specifically to encourage a broad range of additional scientific investigations with this unique data.

During fiscal year 1984, the assessment and evaluation of human and natural perturbations on the stratospheric ozone layer and the atmospheric chemistry and dynamics that drive those perturbations will be continued. The development of one, two, and three dimensional models which couple radiative, dynamic and chemical processes will be continued; as will investigations and measurements of atmospheric trace chemical species and atmospheric winds throughout the atmosphere. Also, the global tropospheric ozone concentration distribution and the factors that control it will continue to be studied. In addition, there will be continued emphasis on the analysis of satellite data sets (Nimbus-6, -7 and Solar Mesosphere Explorer), as well as a modest expansion of research into the mesosphere.

The balloon program will be continued at a level approximately 30–45 flights during 1984. These balloon flights provide the principal capability to validate the stratospheric photochemistry program. Balloon flights also provide for instrument calibration and intercomparisons of different measurement techniques. Aircraft will provide the major means for studying the global troposphere and tropospheric/stratospheric interchange. Studies of potential development instruments will maintain progress toward the development of spaceborne active and passive measurement capabilities which is required to provide global data on trace species.

Atmospheric Dynamics and Radiation Research and Analysis

The research and analysis activities within the Atmospheric Dynamics and Radiation program comprise a core effort which is fundamental to using space technology to solve problems in atmospheric science. The program includes Global Weather, Severe Storms and Local Weather and Climate research. These research activities involve large-scale atmospheric processes, general circulation, atmospheric-surface interactions, mesoscale processes including severe weather phenomena, and radiation balance studies in order to further man's understanding of the atmosphere on all temporal and spatial scales and to study the capability for measuring these processes from space.

The research and analysis program objectives are to: define and develop techniques for advanced remote sensing; develop algorithms to analyze the remotely sensed observations for purposes of validation and diagnostic studies; model the behavior of the atmosphere on a wide range of temporal and spatial scales; and simulate the capabilities of new remote sensors in order to assess their performance prior to developing actual hardware. These activities consist of an integrated program of research, technology development, environmental measurement, and interpretation. Concepts for advanced sensors are being developed, breadboard instruments are being fabricated for demonstration and assessment, and advanced studies are being conducted to define new systems and missions.

NASA continues to conduct definitions studies of remote sensors to measure wind, temperature, pressure and moisture profiles with improved resolution and accuracy. Full exploitation of data from advanced sensors which are now used operationally by NOAA is being pursued. New techniques to improve the quality of data by removing cloud and moisture contamination will permit the sea and land surface temperature data to be collected with accuracy. Studies of the impact of satellite sounding data on our ability to define the state of the global atmosphere continue to substantiate the value of such data to large-scale predictability. The data sets from the Global Weather Experiment are continuing to provide new insight into the nature and behavior of general circulation. The eruptions of Mount Saint Helens and El Chichon have created unique opportunities in terms of measuring the effects of significant increases in atmospheric aerosol content on the climate and providing unique information on transport processes in the stratosphere. The advanced high speed vector processor has completed acceptance testing and will become operational during FY 1983. This processor will vastly improve our ability to process data faster, to run new and more sophisticated models, and to conduct important numerical studies that were formerly impossible to perform.

During FY 1984, research on atmospheric problems through the use of spaceborne techniques will be continued. In addition, FY 1984 funding is required for: processing space data to obtain useful atomospheric information, developing models which can utilize the advantages of satellite observations, assessing the value of space observations in modeling, and assessing space observing systems through simulation studies. Improved instrument concepts will be tested in the laboratory, or aboard balloons and aircraft. A major effort to collect and process cloud data from the five geostationary and two polar orbiting satellites will be continued during FY 1984 as part of the International Cloud Climatology Project study. Development of active temperature, pressure, and moisture sounders will also be continued during FY 1984. An airborne Doppler lidar system, which will be capable of measuring winds in clear air, will be flown around storm systems to measure the details of their dynamics during FY 1984. In addition, complex models of the storm scale will be run for evaluation, and expanded general circulation models, including up to 25 vertical levels, will be developed and tested.

Oceanic Processes Research and Analysis

The goal of the Oceanic Processes program is to develop and apply spaceborne techniques to advance our understanding of the fundamental behavior of the oceans. The primary objectives are to: process data from past and existing spacecraft (Seasat and Nimbus-7); to make these data available to the community in usable and workable form; assess the performance of sensors to obtain useful geophysical information; and use this information for scientific analysis. All Seasat data have been archived at NOAA in centralized data storage facility, and interactive computer terminals have been installed at five oceanographic research centers. Procedures have been implemented to allow routine processing of Nimbus-7 data without any backlogs.

The capability existing technology to measure oceanographic variable within acceptable limits of accuracy has already been demonstrated. Subsequently, efforts have been focused on scientific analysis of the geophysical data generated by these sensors. In the past year the first global data sets for ocean surface winds have been produced from Seasat scatterometer data, and for ocean wave height from altimeter data. Support of science working groups is being continued to identify science questions addressable by technological capability, to determine observational requirements, and to better define performance specifications for future sensors. Reports by the altimeter, scatterometer, and sea-ice Science Working Groups have recently been published, and a report by the Ocean Color Science Working Groups will be published soon.

During FY 1984, Nimbus-7 data collection and processing will be continued, and several Science Wording Group studies will be completed. Seasat science analysis will also be continued during FY 1984. Work will be continued on the Pilot Ocean Data System implementation, with a major thrust to formulate plans for expansion, to utilize the system to support a sea surface temperature workshop, to archive Nimbus-7 costal zone color scanner data, and to establish a costal zone color scanner/sea surface temperature time series during FY 1984. Definition and refinement of in situ sensors are currently underway and will be continued during FY 1984. These sensors are necessary to reveal the three-dimensional structure of the ocean, as satellite platform observations are limited to the sea surface.

FY 1984 funds are also required to define an observational capability utilizing existing technology to advance our understanding of fundamental ocean behavior. For example, definition of the Ocean Topography Experiment (TOPEX), which will require a dedicated mission employing an altimeter to acquire information on global ocean circulation, will be continued during FY 1984. Piggyback deployment of sensors on satellites sponsored by other government agencies will also be conceptualized in FY 1984, such as a scatterometer on a proposed DOD mission, and an Ocean Color Imager on NOAA's series of meteorological satellites. In addition, discussions will be held with other agencies and foreign governments regarding the possibility of receiving data from their sensors. Some examples of possibilities are the United States Air Force's microwave radiometer and ESA's SAR are possibilities for conducting ice research. Spacebore sensors provide the only existing means for obtaining systematic global observations, which are essential for understanding ocean behavior, and the effects of such behavior on climate and terrestrial processes.

Space Physics Research and Analysis

The space physics research and analysis program is a broadly structured effort to enhance our understanding of the characteristics and behavior of plasmas in space and in the vicinity to the Earth and other planets. These studies include: the complex coupling of the atmosphere with the ionosphere and the magnetosphere; the solar wind and how it interacts with planetary magnetospheres and ionospheres; and, how variations in the solar wind are coupled into the near planetary environment and neutral atmosphere. The discipline also includes the use of space as a laboratory for the study of plasmas in regimes that are unattainable on the Earth. The understanding of the plasmas in the solar system, the only naturally occurring plasmas to which we have direct access, will enable us to refine theories regarding astrophysical plasmas.

The major thrust of the space physics program is directed at studies of the near Earth environment, from the flow of solar wind past the magnetosphere, to manifestations of variations of the plasma environment, detectable near the surface of the Earth. Not only are these studies of great interest, but there is often a practical component concerned with these aspects such as ionospheric influences in communication, global circulation of the atmosphere driven by magnetospheric input, the charging of spacecraft immersed in plasma, and the behavior of antennas and their signals in the magnetosphere.

The present state of the field is one of relative maturity, with an emphasis on multipoint and time sequence measurements and active perturbation experiments rather than isolated exploratory observations. For example, there are presently three spacecraft, the International Sun-Earth Explorer (ISEE) and the two Dynamics Explorer spacecraft, taking such measurements. In addition, the Active Magnetospheric Particle Tracer Explorer (AMPTE), which is scheduled for launch in 1984, will be making time sequence measurements. There is an active program of sounding rocket and balloon investigations aimed principally at spatially or temporally isolated ionospheric or magnetospheric phenomena such as aurora or equatorial ionospheric disturbances. An active theoretical and modeling program and a small supporting laboratory program are also being conducted.

The solar terrestrial theory program continues to provide a strong basis for all of the programs in both solar physics and space plasma physics. Theoretical groups are engaged in research on virtually every aspect of the solar terrestrial problem by using both fundamental process calculations and numerical models of the large scale phenomena.

During FY 1984, NASA will continue its program of suborbital investigations, theoretical and laboratory studies, and analysis of existing data from spacecraft. Particular emphasis will be placed on the analysis of data from ISEE-3, which will spend most of 1983 in the Earth's magnetotail. It will then be redirected to encounter the comet Giacobini-Zinner in early 1984. Definition studies will be continued during FY 1984 for such missions as the Origin of Plasma in the Earth's Neighborhood (OPEN), dedicated Spacelab missions, and payloads for the future Tethered Satellite System.

The solar terrestrial theory program will be continued during FY 1984 to research the full range of phenomena in this portion of the environment. Steps will be initiated to build a comprehensive and quantitative aggregate model of the solar terrestrial interaction.

Shuttle/Spacelab Payload Development (Environmental Observations)

The Space Transportation System offers the unique opportunity for frequent short-duration flight of instruments. The Environmental Observations program has incorporated this new capability in the Shuttle/Spacelab payload development activities in these important aspects: early test, checkout and design of remote sensing instruments for long duration free-flying missions; and short-term atmospheric and environmental data gathering for basic research and analysis where long-term observations are impractical.

The Measurement of Air Pollution from Satellites (MAPS) experiment set is a gas-filter correlation radiometer designed to measure the levels of tropospheric carbon monoxide and the extent of interhemispheric mass transport in the lower atmosphere. The instrument was flown successfully on the Shuttle orbital flight test in November 1981. The instrument performed successfully and obtained approximately 40 hours of data on the global distribution of carbon monoxide in the atmosphere. Data processing and validation is about 40 percent complete with the generation of global carbon monoxide maps pfr analysis. The MAPS experiment set has been approved for a reflight and has been assigned to the OSTA-3 payload, currently scheduled for launch in 1984.

The objective of the Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) experiment is to make detailed measurements of gaseous constituents (e.g., hydrogen chloride, water, ammonia, methane) in the Earth's atmosphere by using the technique of infrared absorption spectroscopy. The data will help determine the compositional structure of the upper atmosphere, including the ozone layer and its spatial variability on a global scale. The instrument delivery is scheduled for 1983 with a planned launch in 1984 on Spacelab-3.

In response to an Announcement of Opportunity, a number of principal investigator class instruments were selected for development and flight as part of the Shuttle/Spacelab payloads program. Payloads under development include Active Cavity Radiometer-I (ACR-I) which is designed to aid in the study of the Earth's climate and the physical behavior of the Sun. The instrument was delivered to the Kennedy Space Center in 1982 for flight on Spacelab-1 in 1983. A program for reflight of ACR-1 is being developed. Other experiments selected for reflight include certain instruments developed for flight on the Shuttle orbital flight tests, which will be reflown on Spacelabs-1, -2, and -3.

FY 1984 funds will be used to support the Measurement of Air Pollution from Satellites (MAPS) science team activities, data reduction and refurbishment for refight in 1984.

The initial flight of the Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) instrument is scheduled for 1984. The FY 1984 funding is required to support the continued science team activities.

FY 1984 funding is required to continue the Active Cavity Radiometer (ACR) data processing, science team activities, and refurbishment for reflight on a future Shuttle mission. Definition studies of a potential free-flyer version of ACR, which is called ACRIM, will also be undertaken. The principal investigator instrument development and reflight program will be continued in FY 1984 with research efforts concentrated on atmosphere chemistry, solar intensity and variability, and upper atmospheric winds.

During FY 1984, preliminary definition and breadboard laboratory activities will be conducted on the Light Detection and Ranging (LIDAR) instrumentation. Discussions are underway with the French regarding the possibility of this becoming a cooperative project.

Operational Satellite Improvement Program (OSIP)

The objectives of the operational satellite improvement program are to perform the research and development activities leading to definition of advanced sensors, spacecraft subsystems, and ground equipment for the operational meteorological satellites. Current activities include the development of the solar backscatter ultraviolet (SBUV) instrument for monitoring of ozone fluctuations in the upper atmosphere; assessment of temperature and moisture profiles acquired by the visible/infrared spin scan radiometer/atmospheric sounder (VAS) aboard GOES-4 and GOES-5; and implementation of improvements to the high resolution infrared sounder (HIRS).

The Critical Design Review for the solar backscatter ultraviolet instrument was held in 1982. Delivery of the first unit for integration and launch on NOAA-F is planned for 1983. The design of the high resolution infrared sounder instrument improvements is in process and will be implemented in the units to be flown on NOAA-H, -I, and -J. The visable/infrared spin scan radiometer/atmospheric sounder investigations have shown that the instrument can detect and monitor meteorological conditions which are a precursor to severe storm development.

In the future, the National Oceanic and Atmospheric Administration (NOAA) will be responsible for defining and funding specific system improvements required for their operational missions. NASA will retain its role as system implementation agency for NOAA on a reimbursable basis when new or improved measurements or systems are required. The FY 1984 funding is required to phase out the NASA Operational Satellite Improvement program. These funds will provide for completion of the high resolution infrared sounder instruments and the solar backscatter ultraviolet instruments.

Earth Radiation Budget Experiment

The objective of the Earth Radiation Budget Experiment (ERBE) is to measure the temporal and spatial variations in the radiation balance over the globe. General agreement exists within the scientific community that the Earth's radiation budget must be monitored from space if we are to gain basic insight into the reason for climatic fluctuations.

Experimental Earth radiation budget instruments have been flown on the Nimbus satellites, and sampling studies based on those experiments have shown that adequate global coverage requires a multiple satellite system. These studies also indicate the need for improved calibration of the sensors. Earth radiation budget measurements covering at least one full cycle of seasons are needed. In order to provide concurrent observations from one polar orbiting and one inclined orbit satellite, identical Earth radiation budget instruments will be installed on the NOAA-F and G satellites and the TIROS-N series, and on one dedicated NASA observatory at a mid-inclination orbit. The scientific objectives and measurement requirements were developed by a combined NOAA/NASA/university/industry team of scientists.

Development of the ERBE instruments is proceeding satisfactorily. The Critical Design Review was completed in June 1982. Delivery of the three ERBE instrument flight models is scheduled for 1983.

In addition to the ERBE instruments, the NASA observatory will carry the Stratospheric Aerosol and Gas Experiment (SAGE II). This instrument will provide aerosol measurement data. Both the preliminary and critical design reviews of the SAGE II instrument were completed in 1982. Delivery of the flight hardware is scheduled for 1983.

The Earth Radiation Budget Satellite (ERBS) critical design review was completed in early 1982. The ERBS observatory will be launched by the Shuttle to an altitude of 300km and will then be propelled to the operational altitude of 600km by an auxiliary onboard propulsion system. The planned launch dates for ERBS and for NOAA-F and G are scheduled for 1984 and 1986, respectively.

Extended Mission Operations (Environmental Observations)

The objectives of the extended mission operations is to provide for the operations, data processing, validation and data analysis of missions which have completed basic operations. This currently includes nine spacecraft.

Launched in 1972, 1975 and 1978, respectively, the Nimbus-5, -6, and -7 spacecraft continue to provide significant quantities of global data on sea ice coverage, atmospheric dynamics and chemistry, the Earth's radiation budget, ocean temperature and ocean color. Preliminary evaluation of this data has demonstrated the utility of the measurements, and the instrument techniques are starting to be used on operational satellites. Reduction and validation of this data is continuing, as is the operation of the satellites themselves. There is a strong demand for historical and current data on radiation budget, atmospheric dynamics, and trace constituent concentrations and distribution, as all of this data contributes to global weather trend studies, severe storm analysis and prediction, improved numerical forecast models, ozone concentration trend analysis, and Earth climate studies.

An important contributor to the ozone and aerosol data base is the Stratospheric Aerosol and Gas Experiment (SAGE) satellite which was launched in early 1979. The measurements by this satellite of the stratospheric aerosol loading from the Mt. Saint Helens volcano eruptions have contributed significantly to our overall understanding of natural perturbations to the stratosphere and the potential effect on weather and climate. The SAGE spacecraft subsequently experienced operational problems and was lost in April 1982. Data processing will be completed in FY 1984.

The Solar Mesosphere Explorer (SME), launched in October 1981, is providing major input into our overall atmospheric parameter data base. SME is making some of the simultaneous measurements needed to understand the complex chemical processes taking place in the mesosphere. Included in the data set are measurements of ozone, atomic oxygen, nitric oxide and temperature. The four ultraviolet instruments and the infrared instrument are fuctioning well. Early data results indicate greater short-term variations and magnitude than was expected of many of the atmospheric properties. SME also continues to make measurements of the El Chichon volcanic cloud. Not only is this data valuable to the understanding the short-term impact of volcanoes on the Earth's atmosphere, but it will provide data for use in the study of El Chicon's effect on the climate. A ground truth program to aid in the validation of the SME data is also being initiated. The International Ultraviolet Explorer (IUE) and International Sun-Earth Explorer (ISEE) continue to perform well, with very productive guest investigator programs.

FY 1984 funding is required to support mission operations and data analysis activities on the International Sun-Earth Explorer, the International Ultraviolet Explorer, and the Dynamics Explorer satellites. Processing and validation of data from Nimbus, SAGE, and SME satellites will also be continued in FY 1984 as will activities to provide ground truth data for a NASA-developed ozone instrument to be flown on a NOAA weather satellite. These satellites continue to produce an extremely valuable data on ozone concentrations. This data will be used to estimate the occurrence of natural variations, sea surface temperatures, aerosol measurements, and ocean productivity. In addition, necessary correlative ground truth activity will be continued in FY 1984. These *in situ* observations are essential to verify the quality of remote observations and improve our ability to interpret them.

Upper Atmosphere Research Satellite Experiments (UARSE) and Mission Definition

The Upper Atmosphere Research Satellite (UARS) mission is the next logical step in conducting a comprehensive program of research, technology development and monitoring of the upper atmosphere aimed at improving basic scientific understanding. The UARSE program includes the design and development of the instruments necessary to accomplish the UARS mission and to further define such a mission. These instruments will provide the first integrated global measurements of: ozone concentration; chemical species that affect ozone; energy inputs; temperature; and winds in the stratosphere and mesophere. These measurements will complement the measurements of ozone and of atmospheric parameters affecting ozone that were made on Nimbus and SAGE. The UARS program is a critical element in NASA's overall stratospheric research and monitoring efforts; it will provide the first full data set on stratospheric composition and dynamics which will be required when very difficult decisions must be made in the future regarding production of cholorfluorocarbons. The UARSE instruments will also contribute to the assessment of the impact of stratospheric changes on our climate and will provide the data needed for a full understanding of the stratosphere. These understandings are essential for subsequent design and implementation of a longterm stratospheric monitoring activity.

A final selection of nine experiments has been made; however, further analysis is required to determine if the UARS mission can be conducted at a cost lower than is currently estimated. These nine experiments draw heavily upon the experience derived from earlier satellites. The experiment package includes infrared and microwave limb sounders requiring advances in cryogenics, solid-state devices and microwave antennas beyond the earlier capabilities. Final design and development of the selected instruments and instrument mounting module will proceed. A ground data handling facility, permitting near realtime interactive utilization of data by the investigators is being studied as part of the UARSE activity, along with definition of the mission implementation concept. Mission implementation concepts will continue to be defined consistent with a balance of the measurement needs of the scientific program and alternative concepts of spacecraft requirements so that the cost of this mission can be minimized.

The FY 1984 funds are required for continuation of the detailed design of the instruments, instrument module and observatory detailed design definition and analysis, detailed mission implementation studies, and definition of concept and design requirements for the ground data handling facility. The instruments are the long-leadtime elements of the UARS program. Although there is considerable technological heritage for these instruments, their development and testing in time for a late 1980's launch opportunity requires that substantial progress in instrument design and in interface design i.e., thermal, mechanical, view angles, etc., with the instrument module take place in 1984.

The ground data handling facility will enable a high level of interaction among experimenters and between experimenters and theoreticians than has existed with past programs. Implementation of this concept requires that it be designed early in the UARSE effort so that individual experiment data processing subsystems, including algorithms, and the interactive data base system can be designed for maximum interaction effectiveness.

MATERIALS PROCESSING IN SPACE PROGRAM

FISCAL YEAR 1984 FUNDING LEVEL

Research and analysis	$19,000,000

Materials experiment operations	7,600,000
Total	26,600,000

The Materials Processing in Space program emphasizes the science and technology of processing materials to understand constraints imposed by gravitational forces and the unique capabilities made possible by controlling these processes in the space environment. Ground-based research, technology development, and payload definition activities in FY 1983 are being concentrated on four major processing areas: crystal growth and solidification, containerless processing, bioseparation processes, and fluid and chemical processing. Limited research will be supported in the areas of cloud physics, combustion science, and fluid dynamics. These activities will provide the scientific basis for future space applications of materials processing technology. Definition studies will be performed for Shuttle experiment candidates such as the Acoustic Containerless Experiments System, the Combustion Science System, and the Containerless Measurement System.

Materials Experiment Operations is a consolidation of ongoing activities which provides a range of experimental capabilities for all scientific and commercial participants in the materials processing program. These include drop towers, aircraft and sounding rocket flights, Shuttle mid-deck experiments, and experiments for the Materials Experiment Assembly. These capabilities will enable users to develop different experiments in a cost-effective manner and allow a better understanding of the technical risks associated with experiment concepts before attempting to develop more complex hardware. In addition, limited reflight of currently selected investigations on sounding rockets and on Shuttle/Spacelab missions is provided for in Materials Experiment Operations.

The Shuttle/Spacelab payload development activities have been transferred to the Physics and Astronomy Spacelab Payload Development and Mission Management area to be consistent with the reorganizational responsibilities with the Office of Space Science and Applications.

Research and Analysis (Materials Processing)

The research and analysis activity provides the scientific foundation for all current and future projects in the materials processing in space program. Emphasis is being placed on ground-based research which is expected to be developed into space investigations with potential for future applications. This activity also supports technology development for future ground and space capabilities, equipment definition studies responding to identified space experiment needs, and commercialization activities leading toward privately funded space enterprises. Most research projects are initiated as a result of proposals from the scientific community which are extensively peer reviewed prior to selection. The FY 1983 funding is being used to fund the continuation of three-year research projects proposed by leading members of the materials science community. Ongoing research is concentrated on scientific investigation and technology advancement in infrared detector materials, inertial confinement fusion targets, floating zone crystal growth, separation and synthesis of biological materials, fluid flow effects in materials processing, combustion science, crystal growth, and containerless processing techniques. In addition, some cloud physics research will be initiated as low gravity research opportunities become available. Commercialization activities will continue with studies of institutional arrangements associated with joint NASA/industry ventures, information activities directed toward industry involvement in materials processing in space projects, and negotiations with companies interested in undertaking joint space endeavors with NASA.

Ground-based research and analysis will be continued in FY 1984 in the areas of containerless processing, crystal growth, solidification, fluid behavior, biological separation, combustion, and cloud physics. Prior materials processing in space research has brought three containerless processing techniques (acoustic, electrostatic, and electromagnetic) to the design stage. FY 1984 studies of crystal growth, solidification, and fluid behavior will continue in order to define the role of gravity-driven influences (convection, sedimentation, and buoyancy) in generic processing methods, and will concentrate on materials of technological significance (infrared and nuclear detectors, magnetic alloys and immiscible alloys). Major FY 1984 efforts will also include studies of superconductors, metallic glasses, and other metastable phases where enhanced or new properties may be achieved. Arrangements with companies that may lead to joint ventures in space processing and manufacturing will continue to be reviewed in FY 1984. A small effort in space materials systems will also be continued in FY 1984 as part of an ongoing study effort to identify cost effective utilization of extraterrestrial materials.

Materials Experiment Operations

The Materials Experiment Operations program provides a wide range of opportunities for scientific (e.g., metastable superconducting state of Niobium-gemanium compound) and commercial experiments (e.g., the INCO Technical Exchange Agreement on electroplating) in materials processing in space. Facilities generally used include drop towers, drop tubes, aircraft and sounding rocket flights. Development of Shuttle mid-deck experiments are also supported under this activity. The first materials experiment assembly hardware was completed in 1982 and is scheduled for launch in 1983.

FY 1984 activities in materials experiment operations will continue basic research activities using mid-deck experiments, continue use of the materials experiment assembly (MEA-A), and ground-based, low gravity experimentation. The mid-deck experiments will include investigations which use the first version of acoustic containerless processing equipment and the first low gravity test of a method (isoelectric focused electrophoresis) for the separation of biological materials. Use of short-term, low gravity ground based facilities will be increased to take particular advantage of the new (91 meter) drop tube/tower which became available in 1982. This will be used to study the solidification of metastable and deeply undercooled alloys which may possess new and attractive physical properties.

COMMUNICATIONS PROGRAM

FISCAL YEAR 1984 FUNDING LEVEL

Research and analysis	$8,500,000
Search and rescue	3,800,000
Technical consultation and support studies	2,700,000
Experiment coordination and operations support	1,100,000
Advanced communications technology satellite	5,000,000
Total	21,100,000

The Communications program provides, among other objectives, the technology that allows the most effective use of the geosynchronous orbit and radio frequency spectrum. In prior years, a major portion of the program resources were concentrated in the research and analysis element of the program, which is focused on new communications subsystem technology.

In FY 1983, contracts are being continued with industry to develop a technology base in advanced communications for the 1990's. These efforts, which will be completed in FY 1984, will produce laboratory models of multibeam antennas and onboard switching, signal processing, and radio frequency components.

The Search and Rescue program uses satellites to aid in the detection and location of distress beacons carried by aircraft and ships. The demonstration and evaluation phase began in 1982 with the launch of the Soviet satellite, COSPAS 1. The search and rescue antennas, receivers, signal processor and transmitter for the NOAA-E spacecraft have been integrated and tested, completing all necessary preparations for launch of NOAA-E in 1983. In FY 1982, the ground station development was also completed. Three ground stations were installed at search and rescue facilities operated by the U.S. Coast Guard and the U.S. Air Force. Experimental distress transmitters operating at 406 MHz have been completed and deployed in accordance with the demonstration and evaluation plan. This work has been done in cooperation with Canada, France, and the Soviet Union. Payloads will be flown on six meteorological spacecraft operated by the National Oceanic and Atmospheric Administration, and at least two Soviet COSPAS spacecraft.

Technical consultation and support will continue to provide for studies of radio interference, propagation, and special system studies required for the growth of existing satellite services and the inclusion of new satellite applications. Support to the Department of State, the Federal Communications Commission, and the National Telecommunications and Information Administration, in preparing for a series of World Administrative Radio Conferences on geostationary orbit planning for all space services is continuing, as are direct broadcast satellite mobile communications planning activities.

Experiment coordination and operations support was continued for ATS-1, -3, and -5 satellites in FY 1982. The relocation of ATS-1 to enable continued operations in the Western Pacific has been completed. Current efforts are directed at developing user protocol documents to assist other agencies in the use of these satellites for public service. The Advanced Communications Technology Satellite (ACTS) technology development process is being continued in FY 1983.

Research and Analysis (Communications)

The Communications Research and Analysis program provides the advanced technology base in the field of satellite communications. Currently, there are seventeen U.S. commercial communications satellites located above the Equator in view of the United States. Applications are on file for 24 more to be launched by the mid-1980's. These satellites will exhaust the capacity of the geostationary arc at the lower frequency bands currently in use. Capacity increases beyond the mid-1980's will require systems using new technology advances that function most efficiently in higher frequency bands.

In FY 1980 and 1981, a series of technology development contracts was awarded to U.S. industry to produce proof-of-concept models of components and subsystems that will permit satellite communications operations in the 30/20 GHz frequency band. Contracts were awarded in the following technology areas: multiple spot-beam spacecraft antennas, spacecraft matrix switches, a spacecraft baseband processor, a 30 GHz spacecraft receiver, a 20 GHz solid state spacecraft transmitter, a 20 GHz spacecraft traveling-wave tube amplifier, a traveling-wave tube power supply, and components for low cost ground terminals. Several of these contracts have been jointly funded by NASA and the Department of Defense because of their potential applicability to future military systems. The proof-of-concept models produced by these contractors will be delivered in 1983 and 1984, and will undergo limited end-to-end testing to evaluate their system level performance.

In FY 1984, the research and analysis funding will allow for the completion of the development of the Advanced Communications Technology Satellite (ACTS) proof-of-concept models, allow intensive in-house system testing to be conducted, and allow additional definition of ACTS space and ground technology requirements. In addition, effort will be initiated to define new technology for intersatellite links.

Search and Rescue

The Search and Rescue program is demonstrating the feasibility of using satellites to significantly improve the capability of search and rescue forces to detect and locate distress signals from general aviation aircraft and marine vessels during an emergency. A satellite system can provide more comprehensive coverage than the irregular coverage provided by overflying aircraft now relied upon by permitting rescue forces to arrive at the accident scene more quickly than is presently possible. Recent experience with the COSPAS-1 spacecraft, launched by the Soviet Union in June 1982, has shown that a satellite orbiting in low Earth orbit can detect the emergency beacons operating at 121.5 MHz presently carried by aircraft and ships much more quickly and precisely than can random aircraft overflights. Actual test results indicate that a satellite can fix the position of these beacons to an accuracy of about 15–20 kilometers. The results also show that this same system can locate a proposed new beacon (using the recently allocated 406 MHz frequency), with its stronger and more stable signal, to better than 5 kilometers accuracy.

This multiagency program is being conducted jointly with Canada, France, Norway, the United Kingdom and the Soviet Union. The United States will provide a spacecraft, antennas, launch vehicle, and U.S. ground stations. The Canadians will provide the space telecommunications equipment and a ground station. France will provide an onboard processor and receiver and a ground station. The Soviet Union will launch and maintain two spacecraft operationally compatible with the United States, French and Canadian systems, and will operate their own ground stations. Norway will participate in the joint project as an investigator by providing additional experimental test beacons and an interoperable ground station in Norway. The United Kingdom will provide additional test beacons in the U.K. search and rescue areas. In addition to NASA, United States participants include the Department of Defense and Department of Transportation, which have purchased ground stations and will participate in the program demonstration and evaluation phase. NOAA is providing the spacecraft.

All activities required to support the demonstration and evaluation phase of the multiagency program are completed. The NOAA-E spacecraft is complete; the French and Canadian search and rescue instruments have been delivered and integrated; and the spacecraft has completed thermal/vacuum testing, and is scheduled for launch in early 1983. The three search and rescue ground stations have been completed and are in use with COSPAS-1. New experimental distress transmitters operating at 406 MHz have been developed. Excellent progress has been made in evaluating the effectiveness of the system by using COSPAS-1.

The FY 1984 funding is required to evaluate the performance of the on-orbit search and rescue system to determine overall system effectiveness, location accuracy, and impact on search and rescue operations. FY 1984 funds will also be used to complete the integration and test of the search and rescue instruments on the NOAA-F and G spacecraft. In addition, work will continue in FY 1984 on the NOAA-H, I and J spacecraft to permit an extension of the search and rescue spacecraft coverage on an interim basis until an operational system can be deployed.

Technical Consultation and Support Studies

Radio interference, propagation, and system studies being conducted under this program are required to enable the growth of existing satellite services and the extension of new satellite applications. Unique analytical tools are developed and used to solve problems of inter- and intra-satellite/terrestrial system interference. These efforts provide a technical basis for regulatory and policy studies and are needed to continue orderly satellite services. Emphasis is being placed on on-orbit and spectrum utilization studies which include the development of frequency and orbit sharing techniques and strategies, design standards, and the determination of the effect of propagation phenomena and man-made noise on performance, design, and efficient use of the geostationary orbit and radio spectrum. NASA's unique resources and expertise, developed over more than 15 years, are also used, upon request, to support the Federal Communications Commission, National Telecommunications Information Administration, Department of State, Federal

Emergency Management Agency, and other organizations. NASA will assist in the preparation for the 1983 Regional Administrative Radio Conference to be held in Geneva in June and July of 1983.

The technical consultation and support program has made it possible to implement, on a commercial and nonexperimental basis, remote sensing, mobile communications, and broadcasting by satellite. These capabilities are essential to a broad range of public and private sector applications such as commercial mobile telephone, direct television and audio broadcast, paging, disaster communications, law enforcement, health and education, interstate commerce, and terrorism control. These capabilities will provide valuable contributions to domestic and international economic and social development.

Major emphasis during FY 1984 will include continued activities to assure space communications development through adequate U.S. strategies, positions, technologies, and propagation experiments needed to support U.S. positions at International Telecommunications Union World Administrative Radio Conferences scheduled for the 1984–1988 time frame.

Experiment Coordination and Operations Support

The objective of this program is to continue experiment support for ATS–1, –3, and –5 spacecraft and to appropriately document and archive a wide range of user experiments and demonstrations in the application of satellite communications. Past experiments on experimental satellites (Application Technology Satellite (ATS) series and Communications Technology Satellite (CTS)) have generated great interest nationally and internationally in satellite telecommunications. Nearly 400 communication experiments using the ATS series and CTS have been successfully conducted during the extended lifetime of these satellites; thus providing users with the experience necessary for making informed decisions regarding their communication functions. NASA's stimulus in encouraging use of these unique facilities has led to wider application of commercial satellites, which can now better meet the need for flexibility and continuity of services. ATS–1 and ATS–3 are currently used for VHF voice communication experiments in health care delivery, education, public safety, emergency communications, mobile land and maritime communications, research support and data communication. The major experiments on ATS–1 involve communications in the islands of the Pacific Basin where, for much of that region, the ATS–1 is the only source of inter-island communications.

A major accomplishment of this program was the completion in FY 1983 of the first phase of the Pacific Basin Communications Study, funded by the National Telecommunications Information Administration and NASA, which assessed present telecommunication systems in the Pacific island regions, examined user needs and services, and proposed alternative technological solutions for a regional satellite-based communications system.

Other activities in this program include planning for educational and public service communication, continuing support for the management and operation of the Denver Satellite Access Facility, and the coordination of ATS user experiments with other Federal agencies.

ATS-1, 3 and 5 operations will be continued during FY 1984 as will support for the Denver Satellite Access Facility. The Pacific Basin Study will conclude with an evaluation of the technical characteristics of a Pacific island satellite-based telecommunications network. A study of ATS-1 follow-on options and alternative low density system concepts will also be conducted in FY 1984.

Advanced Communications Technology Satellite

The objective of the Advanced Communications Technology Satellite (ACTS) project is to prove the feasibility of advanced communications satellite technologies in the environment of space and representative Earth atmospheric conditions. The specific technologies which will be validated include: (a) the use of multiple fixed and scanning spot antenna beams; (b) frequency reuse; (c) beam interconnectivity at both intermediate frequenices and at baseband; (d) advanced system network concepts, and (e) dynamic rain compensation techniques. The ACTS project will greatly enhance U.S. space communication technology in the 1990's, preserving this important industry from dominance by emerging competitors.

The request for proposals will be released to industry in early 1983 based on the assumption of significant cost contribution by industry. The launch date is projected for mid-1988.

The FY 1984 funding is required for initiation of design and development activities on the Advanced Communications Technology Satellite (ACTS) project. The current planning estimate for the government cost on the ACTS project is approximately $350 million. This estimate assumes that industry will make a significant cost contribution toward the development of the Advanced Communications Technology Satellite with a resultant sharing of the total program cost. However, the exact nature and amount of possible industry contribution will not be known until proposals have been received from industry.

INFORMATION SYSTEMS PROGRAM

FISCAL YEAR 1984 FUNDING LEVEL

Data systems	$8,900,000

The objectives of the Information Systems programs are to: develop and demonstrate advanced capabilities for managing, distributing, and processing data and information; implement information systems standards and provide transportable common software in order to lower data systems costs; and develop the basis for data services to provide improved access to, and rapid delivery of, space data and advanced data systems in support of the Nation's satellite programs and the space science and applications projects.

This program provides for timely development of data systems capabilities to meet the needs of flight missions and major space science and applications programs. The early demonstration of capabilities has a high potential for reducing ground data systems development risks and the chance of late data delivery.

The FY 1984 information systems funding is required to provide support for space science and applications programs. Specifically, funds are required: to continue development of the oceans and atmosphere pilot projects, which are prototypes of possible future data systems, at the Jet Propulsion Laboratory and Goddard Space Flight Center; to complete implementation of online catalogs and common software for climate and oceans data that support ongoing discipline research; and to continue development of data management standards with flight projects, discipline program offices, and other NASA program offices.

The FY 1984 funding will also provide for: the completion of transportable applications software systems; upgrading of the National Space Science Data Center and the Science and Applications Computing Center; technical data system support for flight projects and Spacelab missions; the continuation of high priority data systems standards research and development activities; and definition of joint pilot activities with the National Oceanic and Atmospheric Administration, the Department of the Interior, and the National Bureau of Standards.

7. TECHNOLOGY UTILIZATION, $10,000,000

FISCAL YEAR 1984 FUNDING LEVEL

Technology dissemination	$3,200,000
Technology applications	6,800,000
Total	10,000,000

The NASA technology utilization program is designed to enhance national economic growth and productivity through the transfer of new technology resulting from NASA research and development programs to the nonaerospace sectors of the economy. In addition to generating use of aerospace technology in United States industry, such technological advances have found use in important public sector areas such as medicine, transportation, environment and public safety. The specific objectives of the program are:

To accelerate and facilitate the application and use of new technology thus shortening the time between development of advanced aeronautics and space technologies and their full use in the economy;

To encourage multiple secondary uses of NASA technology in industry, education, and Government where a wide spectrum of technological problems and needs exist;

To understand more fully the technology transfer process and its impact on the economy; and

To develop applications of NASA's aerospace expertise—its technology, technologists, and unique facilities—to the nonaerospace needs of the Nation.

Since the program's inception in FY 1962, many transfer mechanisms have been developed to facilitate the use of aerospace technology in the public and private sectors of the economy. These mechanisms include publications and announcements, industrial conferences, and seminars. Through such efforts, NASA has developed a viable working relationship with U.S. industry across a broad front of commercial enterprises. In FY 1984, NASA proposes to build on its technology transfer activities to strengthen expanded Government-industry cooperation.

Conversion of NASA Tech Briefs, one of NASA's primary new technology transfer and announcement mechanisms, to paid subscription, is being examined. In 1982, 75,000 free distribution copies were made available routinely to industrial scientists, engineers, and businessmen each quarter to stimulate and promote the application and use of NASA-developed technologies for commercial purposes.

During 1982, the NASA dissemination center network provided nearly 15,000 U.S. industrial client firms with technical information and technology transfer services based on problem-related inquiries. Client firms, especially in the industrial manufacturing sector, have found information and technology transfer services to be beneficial in the development of new or improved products or processes. The NASA-sponsored Computer Software and Management Information Center also had an outstanding year in the sale/lease of NASA-developed computer programs to industry. The entire university-based dissemination network received over $4,000,000 from industry last year for information dissemination and technology transfer services, reflecting substantial continued interest and utility of these NASA-supported programs.

NASA continued its series of industrial conferences and seminars at selected NASA field centers under cosponsorship with the American Institute of Aeronautics and Astronautics (AIAA). A fall conference on materials technology at Langley Research Center marked a change in the conference/seminar formats. Prior events covered a broad range of scientific and engineering advances resulting from projects conducted at the host Center. The new format focuses on selected technological disciplines or fields of interest so that more in-depth treatment of subject matter is made possible. In addition, a special conference was held at the Johnson Space Center recently to relate specific technological advancements in Shuttle tile development for possible applications in industry.

Emphasis during FY 1982 was placed on bioengineering, rehabilitation, manufacturing and productivity applications. Each of the projects funded during 1982 had joint participation from user agencies or industry. A major milestone was reached in bioengineering, when the Programmable Implantable Medication System was successfully implanted and tested in several diabetic animals. An ultrasonic bolt monitor, which can be used to determine if a bolt has a hairline crack through the use of ultrasonic sound, was successfully demonstrated on mine roof bolts (bolts used to hold the ceiling or roof of a coal mine in place). The Bureau of Mines is presently field testing this instrument. NASA and the National Institute of Handicapped Research successfully commercialized a new wheelchair concept for use in commercial air travel, and a major commercial airline has ordered 22 chairs for use in its new Boeing 767.

TECHNOLOGY DISSEMINATION

FISCAL YEAR 1984 FUNDING LEVEL

Technology dissemination	$3,200,000

In FY 1984, NASA will continue to provide for the widest practicable dissemination of technical information resulting from NASA research and development programs. Funding in FY 1984 will allow for continuation of the dissemination of information concerning NASA technology, but at a somewhat lower level than FY 1983. NASA will attempt to maintain price levels for technical information for United States industry so that access by small business users will not be seriously impaired.

NASA is currently conducting its evaluation and benefit analysis activites to determine areas of United States industrial need where aerospace technology may have particular applicability. In addition, program elements are being reviewed in detail to determine the practicality of greater private sector involvement in the technology transfer process. In FY 1984, program evaluation and benefit analysis activities will be phased out; however, publication inquiry support and scientific and technical information data base support for the NASA dissemination center network will be maintained at the NASA Scientific and Technical Information Facility.

TECHNOLOGY APPLICATIONS

FISCAL YEAR 1984 FUNDING LEVEL

Technology applications	$6,800,000

In FY 1984, the applications engineering program efforts will be focused on targeted opportunities in the biomedical field; however, a portion of the program will sustain a small effort in industrial automation (robotics). NASA will continue to participate with industry, other federal agencies and universities to complete several high priority biomedical projects. Applications team activities will be maintained in support of selected feasibility studies designed to apply existing aerospace technology to biomedical and rehabilitation problems identified in cooperation with the National Institutes of Health, other public sector medical organizations, and industry. To achieve this objective, NASA will reduce its level of support in the applications of aerospace technology in transportation, public safety, environment, and manufacturing.

8. AERONAUTICAL RESEARCH AND TECHNOLOGY, $311,600,000

FISCAL YEAR 1984 FUNDING LEVEL

Research and technology base	$205,100,000
Systems technology programs	106,500,000
Total	311,600,000

The objectives of the aeronautics program are to advance aeronautical technology to insure safer, more economical, efficient, and environmentally acceptable air transportation systems which are responsive to current and projected national needs; to support the Department of Defense in maintaining the superiority of the Nation's military aircraft; and to maintain the strong competitive position of the United States in the international aviation marketplace.

The FY 1984 program supports these objectives by providing for technology advances in all aeronautical disciplines, stressing the technology areas judged to be the most critical by in-house assessments, industry, military, and advisory groups, and other users of technology within and outside the Federal government. Emphasis will be placed on maintaining a strong discipline and vehicle oriented research and technology base, with focused systems technology programs in high-performance and subsonic aircraft rotorcraft and propulsion technology.

Numerical aerodynamic simulation is an important new initiative for FY 1984 in system technology. This program leads toward major advances in the Nation's capabilities in computational fluid dynamics culminating in new powerful analytical techniques that will be invaluable in the design of future aerodynamic vehicles of all types.

RESEARCH AND TECHNOLOGY BASE

FISCAL YEAR 1984 FUNDING LEVEL

Fluid and thermal physics research and technology	$52,200,000
Material and structures research and technology	27,700,000
Controls and guidance research and technology	12,800,000
Human factors research and technology	11,200,000
Multidisciplinary research	3,700,000
Computer science and applications research and technology	20,800,000
Propulsion system research and technology	28,500,000
Rotorcraft research and technology	23,300,000
High-performance aircraft research and technology	38,600,000
Subsonic aircraft research and technology	9,000,000
General reduction	22,700,000
Total	205,100,000

Fluid and Thermal Physics Research and Technology

The objectives of the fluid and thermal physics research and technology program are to: (1) advance the speed and scope of computations for the prediction of fluid dynamic flows over aircraft and in turbomachinery; (2) develop practical means to improve the aerodynamic efficiency and environmental acceptability of aircraft and propulsion systems; and (3) provide the experimental technology required for precise aerodynamic testing. The attainment of these goals will permit the confident design and development of new aircraft and engines with minimum time and cost while providing the widest range of design options.

Of the broad areas of application of fluid dynamics, the most advanced is that of external flows over wings, bodies, and simple combinations of the two. A new pseudo-spectral technique for solving Euler's equation of fluid motion has been applied to several difficult shock wave problems and has resulted in a three-fold increase in solution speed over standard techniques. Computation of internal and rotational flows in compressors and turbines is progressing at a rapid rate but is presently less accurate than that for external flows for design application because of the greater geometric complexity and impact of difficult viscous flow interactions. Nevertheless, during FY 1982, shock-free transonic flow codes were applied to the analysis of compressor blade flows, providing new understanding of the causes of flow separation. The research offers promise of design cost savings by reduction in the number of experimental blade sets normally required in compressor and turbine design.

Experimental studies to reduce fluid friction drag of airfoils, compressor and turbine blades, and complete aircraft have confirmed preliminary results showing 20 percent reductions in turbulent friction drag; and new wind-tunnel results have demonstrated that laminar boundary layers on transonic airfoils can be maintained over 90 percent of the airfoil's chord. Laminar flow research at supersonic speeds that was previously restricted to flight testing is now feasible in a new wind-tunnel design that quiets the flow to disturbance levels of free flight. Transition Reynolds numbers equal to those of free flight have been demonstrated in a pilot facility at a Mach number of 3.5.

Basic investigations of the combustion of liquid fuels have focused on the causes of soot formation and associated undesirable radiative heat transfer to combustor walls. These studies have defined the influence of fuel chemical properties as well as the mechanics of spray mixing and droplet evaporation on the combustion processes. Details of these studies are being integrated into analytical codes for ultimate application to the design of combustors with extended life.

The unique new cryogenic transonic wind tunnel, the National Transonic Facility, was completed in FY 1982 and is undergoing final checkout before beginning a test program to explore the effects of Reynolds number on aircraft performance, maximum lift capability, and stability and control. New models of a typical fighter and a transport aircraft were completed, using recently developed fabrication techniques, and have been validated for the extreme cryogenic test conditions.

Research in computational fluid mechanics during 1984 will be maintained at the current funding levels; however, the natural development of the science will bring greater emphasis on more exact fluid equations and more complex geometries such as complete aircraft, including the empennage, and the rotating flow passages in trubomachinery. Continued effort will be made to increase computational speed and accuracy through algorithm developments which will produce a more rapid convergence of numerical iterative procedures. Computational advances in flow prediction in turbomachinery will be supplemented by experimental measurements utilizing specialized test rigs designed for validation of computer codes and simplified to allow isolation of the effects of individual physical phenomena.

Turbulence research will be directed in greater part toward flow visualization for characterizing the typical flow structures convected downstream in turbulent boundary layers. Increased attention will be given to the effects of noise and surface irregularities on the transition from laminar to turbulent flows. This research will lead to improved methods to predict and reduce aircraft drag.

Combustion research will focus more sharply on fundamentals influencing the chemical and related physical progress of the heat release process. Experiments will be designed to identify purely chemical effects as compared with physical-chemical influences known to exist during combustion of sprayed droplets in typical engine combustors.

Experimental aerodynamics will place emphasis on the achievement of higher levels of maximum useful lift from wings and other airfoils. This research will be designed to meet the needs for increased maneuverability for fighter aircraft at both transonic and supersonic speeds, as well as for transport configurations where increased high lift permits design trade-offs leading to increased performance. During fiscal year 1984, the capabilities of the National Transonic Facility will be utilized to provide for real-time assessment of the aeroelastic deformations of the models and studies will be conducted to determine the optimum means for simulation of propulsion effects. Important decision milestones on the use of magnetic balance systems and adaptive walls whould be reached during fiscal year 1984. The wall and balance support systems in wind tunnels constitute the largest remaining sources of error in wind-tunnel data.

Materials and Structures Research and Technology Program

The objectives of the materials and structures research and technology program are to: (1) investigate and characterize advanced metallic, ceramic, polymer, and composite materials; (2) develop structural concepts and design methods to exploit the use of advanced materials in aircraft; (3) further analytical and experimental methods for determining the behavior of aircraft structures in flight envrionments; and (4) generate research data to promote improvements in performance, safety, durability, and economy in civil and military aircraft. Areas of emphasis include high temperature engine and airframe materials and structural concepts; composite materials application, life prediction, thermal and dynamic response, and aeroelasticity; and more accurate and efficient integrated design methods for airframes and engines.

During the past year, a number of significant accomplishments were realized. The cure temperature of PMR-15 composites was reduced by 100°F through modifications of the matrix-resin chemistry. As a result, these high temperature polyimide composites for engines and airframes can be produced more readily with lower expenditures for energy and capital equipment. Grain boundary oxidation was determined to be the major factor affecting the fatigue life of powder-metallurgy superalloys and the chemical mechanisms controlling hot corrosion of superalloys were identified; these research results provide the basis for subsequent work to increase the useful service life of turbine hot section components. A formal procedure was developed which automatically optimizes turbine fan blades for steady state, vibratory, impact, fatigue and flutter considerations. In aeroelasticity research, adaptive digital active flutter suppression was demonstrated for the first time. The effect of angle-of-attack on flutter was also demonstrated. An F-16E model with a cranked arrow wing underwent wind-tunnel testing and was shown not to have flutter problems. In composites research, by using anisotrophic elasticity principles, a method was developed to determine the strength of angle plied laminates considering stress singularities at cracks, corners and free edges. In studies on thick composites for use in heavily loaded airframe applications, both strain-to-failure and fracture toughness were found to decrease as thickness, increased. Intensive studies of impact response characteristics and delamination behavior have led to the identification and initial assessment of several promising resin compositions. A wide collection of improved optimization codes and design-oriented analysis methods have been developed and assembled. These are being integrated into a computer application system for the evaluation and design of a wide range of aerospace vehicles.

Research on high temperature engine materials will emphasize new materials, in particular carbon-carbon, intermetallics, ceramics and tougher, high temperature polymers. Research on improved processing of superalloys and process modeling of material response under thermal loading will be increased, as will the effort to obtain a fundamental understanding of the roles of cobalt, columbium and tantalum in superalloys. Life prediction of materials using viscoplastic modeling techniques will be stressed. The power aluminum program for high speed airframe structural applications, now in its second year, will continue its planned growth.

In the engine structures and structural dynamics programs, research will be focused on the development of fundamental understanding of the behavior of engine seals and rotor dynamics as well as development of accurate and affordable nonlinear analysis methods and optimization methods for rotating systems. Tribological research will increase understanding of adhesion, friction, wear and lubrication of metallic and ceramic materials.

The principal thrusts in composite materials will continue to be durability, damage tolerance and the development of tougher composites. Intensive studies will be conducted in FY 1984 in the following areas: impact response; delamination; damage tolerant concepts such as buffer strips, bonded stringers, and translaminar stitching; and polymer synthesis, characterization and processing. Special attention will be directed at developing an understanding of the relationship between resin properties and composite properties as resin improvements often do not result in corresponding improvements in the properties of composites. The composite structures effort will be directed to exploration of buckling behavior and postbuckling response.

In loads, dynamics, and aeroelastic research, the FY 1984 program will emphasize improved unsteady aerodynamics prediction methods, particularly in the transonic speed range. Aeroelastic analysis tools will be developed and experimentally validated for application to aircraft and to turbine engine rotating components. Active and passive control of aeroelastic behavior will be a major focus. The Drones for Aeroelastic and Structural Testing (DAST) program will provide a flight validation for a flutter suppression system installed on a Firebee drone that has a transport aircraft type supercritical wing. A series of DAST flights are planned in FY 1984 to investigate the flutter suppression system design, compare predicted versus measured flutter boundaries, and determine performance of a gust/maneuver load alleviation system.

The joint NASA/FAA program in transport crash dynamics has resulted in a crash scenario being developed for a full scale crash test of a Boeing 720 transport aircraft. Work related to the development of required instrumentation to support a FY 1984 crash test will be conducted. Fuselage component drop tests will be conducted to obtain necessary structural performance data to support the analytical modeling required for the 720 crash test.

In the area of aircraft integrated analysis and design methods, efforts will focus on the optimization of the structural and aerodynamic configuration using performance and operating costs as design constraints. A large-scale optimization of a transport aircraft wing for fuel efficiency has been defined as a long-term task on which to focus the new methodology.

Controls and Guidance Research and Technology

The objectives of the aircraft controls and guidance research and technology program are to: (1) develop architectures for flight crucial systems for future aircraft and to devise analytical methods and techniques for assessing the reliability and performance of complex integrated fault-tolerant flight control systems; (2) develop mathematical control laws and design methods of extending the performance envelope and reliability of future civil and military aircraft; and (3) investigate emerging technologies which offer future alternative approaches for continued aviation safety and efficiency. Major program elements are: applied control theory, flight path guidance, architectural concepts, system assessment methods, and environmental effects research.

Flight crucial systems research is a major element in the controls and guidance program, and excellent program has been made in developing this technology. Engineering models of two pioneering fault-tolerant computers, fault-tolerant multiprocessor (FTMP) and software implemented fault tolerance (SIFT), were completed and evaluation initiated at the Langley Research Center. CARE III, the computer aided reliability estimation program, and an important analytical tool for assessing the reliability of fault-tolerant systems, has been developed and is undergoing final evaluation. In early 1983, the Avionics Integration Research Laboratory (AIRLAB) at the Langley Research Center commences important research in highly integrated, fault-tolerant electronic systems for aircraft and spacecraft. Concern with the effects of lighting on digital electronics has led to increased research activity both in understanding lighting phenomena and in developing protective techniques. The effectiveness of newly developed protective schemes is being evaluated using induced voltage levels determined from analysis of flight data. Other activities in this area have resulted in a system for random injection of lighting-induced upset transients into microprocessors to characterize the effects.

Significant advances have been made in the determination of a design data base for vehicles with highly-augmented controls. Shuttle data have been analyzed to assess the flying qualities and improve the generic design process and modeling techniques for future aircraft. Improvements in analytical techniques provide the capability to determine the influence of different active control concepts on aircraft stability, performance and configuration. Aircraft flight experiments have been conducted to validate advanced control laws which improve aircraft performance in the presence of gusts, clear air turbulence and other disturbances without limiting the control system effectiveness in other flight regimes.

In the area of flight crucial controls, advanced fault-tolerant architectural concepts will be evaluated in the AIRLAB. These concepts will be derived from earlier evaluation of the engineering models of fault-tolerant computers, SIFT and FTMP and from specific system studies. One architectural concept to be evaluated is from a study for an integrated flight and propulsion control system for a high-performance aircraft. Another concept will be for a generic fault-tolerant avionics system for both aircraft and spacecraft applications. To demonstrate the reliability of these systems, research will continue on validation methodology through a series of grants at several key universities with the principal investigators doing research in the AIRLAB. Increased emphasis will be placed on fault-tolerant software with two significant approaches, N-version programming and recovery blocks, evaluated to determine the best approach. The environmental affects area will emphasize the design of concepts and circuits to protect electronics in the presence of lighting strikes. In the propulsion controls area, the principles of fault-tolerant design will be applied to improve system reliability. These concepts will be evaluated in a full scale engine test facility. In an important new area, restructurable controls, the fault tolerance or reconfiguration in the presence of failures will be applied to the entire flight control system and airframe. Research on advanced redundant sensors and actuator concepts will continue.

In the control theory area, the research effort will increase in highly or super augmented aircraft controls. In the design of these aircraft, weight and natural stability are traded for performance, and the aircraft becomes totally dependent on the flight control system. Examples of such aircraft are the F-16 and the Shuttle. Research will provide a data base which includes flying qualities, control power requirements, and design considerations. The concept of non-linear controls will be evaluated for application to high-performance aircraft operating at high angles-of-attack.

Human Factors Research and Technology

The objective of the human factors research and technology program is to provide a technology base for solving human problems impeding the growth and safety of aviation. This is accomplished by developing a fundamental understanding of the capabilities, limitations and tendencies of aircrew members in interacting with each other, with cockpit systems and with the air traffic control system. There are four areas of emphasis in the human factors program: flight management, simulation technology, aviation safety, and research methods.

The flight management research program has continued to develop a basic understanding of information transfer, decision making and resource management in the cockpit in order to provide a data base for improved cockpit systems and operational procedures. In this area, research on Cockpit Display of Traffic Information (CDTI) is continuing in cooperation with the Federal Aviation Administration (FAA). A number of studies have been accomplished on display format, content, symbology and size. In fiscal year 1982, simulation studies demonstrated an increase in runway throughput (landings and takeoff) of up to 20 percent through the use of CDTI. The display used in these studies employed a horizontal plan view format which allowed greater visual perception of the distribution and flow of aircraft in terminal area operations. More recently, a three-dimensional perspective display has been developed which provides pilots with a better understanding of the vertical situation. Evaluation of this new display format is continuing. Other flight management research is focused on developing strategies for allocating functions to crew members and to automation of advanced cockpits. This research was initiated in fiscal year 1982 with a field study of the effect on aircrews of increases in automation in modern aircraft such as the DC-9-80 and the 767. The overall goal of this program is to develop function allocation guidelines which make maximal use of advanced automation technology in view of human capabilities and limitations.

Simulation technology research is aimed at increasing the degree to which man-in-the-loop simulation can replace actual aircraft flight time in research, development and training. Work is continuing on improved simulation of weather hazards, methods for determining required levels of simulation fidelity, and techniques for assessing simulations system performance. Recent accomplishment include definition of required simulation fidelity for the flare maneuver and for wake vortex encounters.

The goal of the aviation safety research program is to identify the physical, psychological and procedural aspects of the aviation environment which tend to induce human error. The two major projects in this area are the Aviation Safety Reporting System (ASRS) which NASA is continuing to manage for the FAA, and a joint NASA/Army/Air Force program to assess the effects of fatigue and circadian desynchronosis on aircrew performance. A review of existing knowledge in this area is being completed, and a field study using short-haul crews has been undertaken.

The goal of the research methods area is to develop crew workload and performance methods which can aid in assessing the relative merits of alternative man/machine interface designs. An empirical evaluation of commonly used workload measures has been completed, and a workload assessment has been completed.

Flight management research will continue to encompass CDTI and the human implications of increased cockpit automation. The CDTI program will change focus from part task simulation studies to full mission scenarios as two major simulators (DC-9 and 727) become available in fiscal year 1984. Application areas will turn toward the implications of CDTI for collision avoidance systems, and toward the study of interactions of multiple aircraft equipped with CDTI. The cockpit automation research will increase and encompass basic research on the interaction between crews and advanced cockpit information input/output systems such as multifunction programmable keyboards and touch-sensitive flat panel displays.

In simulation technology, a model for predicting needed simulation fidelity levels will be evaluated using F-14 flight information, and a major effort will be undertaken to develop the methodology for using full mission simulation to evaluate the effects of malfunctions and other systems problems on crew decision making. Research will continue on improving the capability to simulate weather hazards, and to assess simulation system performance. A physiological measure of brain activity, called evoked potential, will be investigated as a method of evaluating the psychological fidelity of a simulation to the human subject. Fundamental research on how the human visual system perceives computer generated imagery will focus on developing methods for minimizing graphic distortion and misperception of information.

In the area of aviation safety, both the fatigue study and the ASRS will continue. Attempts will be made to increase the use of the ASRS by general aviation pilots. The fatigue and circadian desynchronosis study will expand to include crews on long-haul flights. Differences between commercial air carrier crews and Air Force crews, who differ in age by an average of 20 years, will be investigated.

The research methods area will continue to emphasize workload measurement research. The focus will evolve from the investigation of the components of the subjective workload phenomena, and from an evaluation of available measures, to the development of guidelines for the use of workload metrics for various applications.

Multidisciplinary Research

The objective of the multidisciplinary research program is to conduct novel, long-range, multidisciplinary research related to aeronautics. This research is conducted principally at universities through: (1) the Graduate Program in Aeronautics which supports graduate training and research relevant to both NASA and the universities and conducted, at least in part, at a NASA research center using NASA facilities; and (2) the Computational Fluid Dynamics (CFD) Training program initiated to support graduate CFD training programs in selected universities. The Graduate Training program in Aeronautics was started at the behest of Congress and assures the availability of skilled researchers in the field of aeronautics and provides for excellent interaction among students, faculty and NASA center personnel in the conduct of research. The CFR training program is providing for the development of interdepartmental university curricula and sponsoring graduate CFD training in response to the rapidly escalating need for specialists by NASA, DOD and the national aerospace industry.

The research and graduate student support sponsored under this activity will continue to address a broad range of innovative topics to insure an adequate source of well-trained researchers necessary to contribute to the long-term growth in aeronautics technology. The university research formerly conducted under the Fund for Independent Research (FIR) and the Joint Institute of Advancement of Flight Sciences will be supported through the disciplinary research and technology base programs.

Computer Science and Applications Research and Technology

The objective of the computer science and applications program is to develop an understanding of the fundamental principles underlying aerospace computing and the relationship and trade-offs between algorithms and computing architectures; and to apply this fundamental insight in order to advance computational concepts and improve system architectures. The program being initiated in FY 1983 is guided by a program plan which was completed in 1982. This program has four major areas: concurrent processing, highly reliable cost-effective computing, information management, and computational facilities.

Concurrent processing addresses system architectures and algorithms for computationally-intensive problems in aerospace research, such as computational fluid dynamics and image processing. A new Research Institute for Advanced Computer Science (RIACS) is being established at the Ames Research Center to carry out research in computer science and engineering in areas of potential long-term application to NASA programs.

Research on highly reliable, cost-effective computing focuses on the technology underlying the construction of systems for man-rated flight vehicles. The emphasis is on investigations of fault-tolerant hardware architectures and cost-effective tools and techniques for developing verifiably correct software.

The objective of the research in information management is to exploit technical advances in computers to aid the engineering design and analysis process. The Integrated Program for Aerospace Vehicle Design (IPAD) is continuing research on large-scale design data base management. Techniques to handle basic geometry in a multi-schema (multiview) environment have been developed and implemented and are currently undergoing evaluation.

A major component of the computer science and applications program is to provide state-of-the-art high performance computational resources for aerospace research. Ames Research Center has installed a CRAY 1S–1300 computer with a CDC dual 720 support computer. Lewis Research Center has installed a CRAY 1S–2200 computer utilizing an IBM 370/3033 attached processor for input and output services. These systems are being used for scientific computation in fluid dynamics, chemistry, and thermal and structural analysis.

In FY 1984 the computer science research program will expand efforts in system verification and validation technology for highly reliable systems, and evaluation techniques for managing complexity in large-scale systems. Research in concurrent processing will be initiated, including work in system architectures for parallel processing, programming languages which facilitate concurrency, and a characterization and evaluation of resource management techniques appropriate for operating systems of concurrent machines. The IPAD project will be advancing toward a 1985 establishment of IPAD data base management software on a CDC host computer, including a full geometry capability and limited computer networking. The Finite Element Machine (FEM) architecture will be expanded to a 36 microprocessor configuration, based on the success of an early 4-processor prototype and its successor, the 16-processor machine which will be operational in early 1983.

Propulsion Systems Research and Technology

The objective of the propulsion systems research and technology program is to provide fundamental understanding and generic technology through the verification of computational methods developed under the fluid and thermal physics program and the use of these computational methods to design advanced propulsion components and systems. These technology advances will allow continued future improvements in military and civil aircraft propulsion system efficiency, engine performance, fuel flexibility, reliability, and durability as well as environmental compatibility. The potential of advanced propulsion system concepts is also evaluated within the program. Research is being performed in the areas of turbomachinery, combustion and fuels, propulsion system integration, power transfer, engine systems, controls, and instrumentation. These component and engine system technology advances will lead to major propulsion system improvements in a broad range of military and civil aircraft ranging from small missile and general aviation aircraft to transports, helicopters and high-performance military aircraft.

Major efforts are being made in all of the component areas to acquire detailed data for verification of computational fluid dynamics computer codes. Nonintrusive laser velocimeter data have been obtained for a low aspect ratio fan stage and are being compared to an inviscid three-dimensional Euler code. Laser velocimeter data are also being obtained for three core inlet stages and two controlled diffusion stators. For propellers, laser measurements have been compared to lifting line analysis, and solutions for Euler lifting surface analysis have predicted shock locations agreeing with experimental flow visualization data. The first advanced propeller performance data was obtained at takeoff and climb conditions for comparison with predicted performance. Through use of analysis, turbine cascade flow turning predictions were extended to 75 degrees which is significantly higher than previously possible. Checkout of a new high pressure turbine facility in 1983 will allow creation of an engine environment to correlate cooling data between hot cascade rigs, warm turbine facilities, and the actual engine environment. In combustor research, a multistep kinetic model for soot formation has been developed and reported. Experimental and analytical work is providing data on the effects of broad specification fuels on combustor durability and performance. In inlet research, excellent agreement has been obtained between analysis and sidewall shock boundary layer interactions. Axisymmetric inlets at angle-of-attack have been analyzed for the first time with a fully viscous analysis. Dynamic simulations of compressor and engine systems in stall have been generated for comparison with experimental results. In controls research, real-time engine simulation has been demonstrated on parallel microprocessors. Research on innovative sensors for digital controls continues with the development of a Fabry-Perot temperature sensor. Basic instrumentation research is directed toward development of high temperature sensors and electronics for engine measurements. Silicon carbide crystals appropriate for high temperature electronic devices have been generated for the first time. Approximate and multi-dimensional analytical computer models are being developed for piston and rotary engines. The approximate rotary engine model will be validated this year. Power transfer research has generated a life and reliability analysis for planetary gear trains. An advanced helicopter transmission has been designed and fabricated which is 24 percent lighter than existing transmissions.

In FY 1984, the scope and funding of propulsion system research and technology will be expanded significantly. Additional emphasis will be placed on technology for propulsion system integration and on turbine engine cycle advances to improve performance and survivability.

Turbine engine component research will continue to focus on the verification of component modeling computer analysis and its use for design of advanced configurations. Basic compressor flow measurements by laser doppler velocimeter will be extended to a three-stage rig typical of core inlet stages. Component work will also investigate contrifugal compressors and the scale effects associated with viscous layers and manufacturing limitations. Turbine research will experimentally investigate turbine cooling using the Lewis Research Center's High Pressure Facility for correlation of data with the Center's hot cascade and warm turbine rigs. Analysis of three-dimensional viscous turbine passage flows will also be demonstrated. Propeller research will extend the laser doppler velocimeter data base to off design operation of propellers and comparisons will be made with three-dimensional Euler and potential lifting surface codes. In combustor research, in-house testing will extend the operating pressure and temperature range of fuel property effects on soot, emissions, radiation, ignition and relight. Research on inlets will acquire the first detailed three-dimensional viscous data for axisymmetric supersonic inlets at angle-of-attack. Data at high subsonic speeds will be acquired for offset diffusers and compared to viscous analysis. Nozzle analysis will be extended to cover supersonic non-axisymmetric configurations. Engine systems research will compare dynamic models for engine systems on stall to high by pass General Electric TF34 data and low bypass Pratt and Whitney PW1130 data to be acquired. Multistage compressor in stall data will be acquired to provide better dynamic component modeling. Internal combustion engine research will demonstrate a high output insulated diesel aircraft cylinder, and a turbocharged direct fuel injection rotary engine with advanced seals. Instrumentation research will develop the first high temperature electronic components using a silicon carbide base and initiate fabrication of prototype high temperature pressure transducers.

Rotorcraft Research and Technology

The objectives of the rotorcraft research and technology program are to provide analytical bases in the areas of aerodynamics; flight dynamics and control; man-system integration; structures and dynamics; and wind-tunnel, simulation and flight experiments support. Specific objectives include: (1) analysis of unsteady aerodynamics, transonic flow, blade vortex interaction and wake flow; (2) development of handling qualities criteria; (3) development of a technical base of human information transfer in the unique helicopter cockpit environment; (4) prediction of external noise; (5) reduction in dynamic loads and prediction of vehicle response; (6) long-term evaluation of flight service of composite components; and (7) fundamental understanding of helicopter icing mechanisms. These efforts are complemented by portions of the systems technology program in rotorcraft.

During the past year, progress has been achieved in analyses of rotor unsteady aerodynamics. Three-dimensional analyses for transonic flow, which account for wake vortex interaction, have been completed. Experimental comparisons have also been completed. These new analyses have been made available to the five United States helicopter manufacturers. In addition, small-scale/full-scale wind-tunnel data correlation of fuselage drag prediction methods was completed utilizing the Bell Model 222 fuselage configuration. In the area of handling qualities, research support was provided to the Federal Aviation Administration (FAA) and the Department of Defense (DOD) on flying qualities certification and military specification criteria, respectively. Instrumentation flight decelerating approach experiments were conducted in support of the FAA, and Nap-of-the-Earth (NOE) engine/governor dynamics experiments were conducted on the Vertical Motion Simulator at the Ames Research Center to provide a data base for future military specifications. Human factors research focused on the validation of available techniques to measure pilot workload accurately in the unique helicopter environment. Helicopter noise research received increased emphasis and an acoustic specialists workshop was held to define the state-of-technology and the challenges remaining to achieve a design-for-noise capability. Flight tests were completed using an OH-6 helicopter to explore the vibration reduction potential of higher harmonic control concepts which drive the rotor blade pitch control at high frequencies to nullify rotor vibration forces. The long-term evaluation of composite structural components in various operational environments focused on the return of the initial set of flight components from 206L and S-76 helicopters for laboratory testing at the Langley Research Center. In the area of helicopter icing, a research program was initiated with airfoil testing in the high-speed icing tunnel at the Lewis Research Center to develop ice accretion data as a basis for analytical prediction method development.

A major effort will be undertaken to couple far-wake prediction calculations to the existing transonic airfoil aerodynamics prediction capability to probe low noise rotor design capability. This effort will also explore the trade-offs available by operating at reduced rotor rotational speed. Also, increased activity in circulation control aerodynamics theory will be carried on in support of the X-Wing rotor development program. Rotorcraft aerodynamics research will also include small-scale rotor tests utilizing a new test rig for hover tests of rotor/wing interaction.

In the area of flight dynamics and control, increased effort will be focused on a cooperative program with the FAA aimed at building up a data base for the development of tilt rotor certification criteria. In addition, flight and simulation activities will be continued in support of the DOD update of military handling qualities criteria. This validation experiments will be carried out utilizing extensive flight test data available for the UH-60 helicopter. This validation activity will also address piloted simulation utilizing simulated Global Positioning System (GPS) inputs as a navigation link.

Increased emphasis will be given to the subject of the fundamental understanding of helicopter external noise as a base upon which to build new prediction capability. Small-scale model tests will be conducted to investigate tip vortex induced impulsive noise, broad band noise sources and the relationships between small-scale and large-scale noise data. Research on the understanding and control techniques for helicopter interior noise will also continue.

In the area of vibration reduction, flight tests will be completed and data analysis will be carried out in the investigation of active control concepts for vibration reduction. Flight test data from the OH-6 helicopter will be used to assess the benefits of active control techniques. Open-loop flight data is now available and the closed-loop data will be acquired in FY 1983 as a basis for the extensive data analysis and reporting activity.

Rotocraft structures research will emphasize the investigation of thin gauge composite buckled skin concepts which are a unique aspect of helicopter airframe design. Composite concepts for improved energy absorption and crash safety will also be investigated. Innovative joining and attachment concepts will be explored and curved fuselage frames will be designed, fabricated, and tested to build a design data base. The long-term service evaluation of composites will involve additional static tests of components removed from the field.

Operating problems research will focus on the problems of helicopter icing protection and contingency power requirements. In the area of icing research, the results of icing tunnel tests of helicopter airfoils will be used to investigate the ability to predict the degradation of rotor performance due to ice buildup. This activity will be extended to flight test to determine the extent of correlation between wind-tunnel icing data and actual flight icing build-up and performance degradation. An Army-supplied T700 engine will be extensively instrumented and modified with water injection hardware for testing to provide a data base on the use of water injection for short-term contingency power capability in helicopter turbine engines.

High-Performance Aircraft Research and Technology

The objective of the high-performance aircraft research and technology advancements needed to establish and maintain technological superiority in high speed aircraft and missiles, including powered-lift aircraft with conventional or short takeoff and landing capabilities (V/STOL), supersonic cruise and maneuver aircraft with conventional or short takeoff and landing characteristics, and hypersonic cruise aircraft.

In powered-lift research and technology, emphasis continues on the development and verification of analytical prediction methods essential to development of efficient and effective military V/STOL aircraft. Aerodynamic performance characteristics were obtained from high-apeed wind-tunnel tests of several twin-engine, high-speed fighter/attack aircraft concepts which included tandem fan, remote augmentor lift, and augmentor ejector propulsion systems. Promising single engine aircraft concepts resulting from recently completed system studies will also undergo high-speed wind-tunnel testing in FY 1983 to determine their aerodynamic performance characteristics. In flight dynamics, extensive analysis of high angle-of-attack flight characteristics, stall/spin behavior, and improved low-speed combat maneuverability were conducted for a family of advanced fighter aircraft concepts. Piloted simulation studies have investigated control system requirements for integration of thrust vectoring with aerodynamic controls and for utilizing thrust vectoring throughout the flight envelope. In aerodynamics and propulsion integration, NASA cooperative efforts are being pursued with industry on high-performance military airplane wing and leading edge design concepts in combined analytical/experimental programs. During the last year methodology was defined for integrating empennages into single and twin engine fighter aircraft with thrust reversal. Extensive wind-tunnel testing of advanced fighter concepts with integrated non-axisymmetric nozzles is continuing to provide verification of prediction methods and for development of a parametric data base.

High-performance aircraft controls technology studies have been completed and a program is underway to evolve new system architectures for highly integrated airframe and propulsion controls applicable to future high-performance aircraft having strong airframe/propulsion interactions by building upon extensive experience in digital fly-by-wire airframe and digital engine controls.

Essentially all of the selected work carried over following termination of the supersonic cruise research program has been completed. The high speed aircraft structures activities have been redirected in-house at the Langley Research Center to titanium fabrication techniques using superplastic forming and weld brazing processes. The activities in supersonic cruise aerodynamics and configuration development have been directed to military concepts. The axisymmetric inlet configuration with translating centerbodies has been documented over the full operating speed range. Research emphasis has shifted to variable diameter centerbodies, half axisymmetric, and conformal variable geometry inlet concepts.

Work on dual engine high-speed vehicle concepts is continuing with special emphasis on propulsion system, variable geometry nozzle, and two-dimensional inlet integration Dual-mode (subsonic/supersonic combustion) ramjet development is continuing. Work with liquid hydrogen fuel with subsonic combustion in fixed geometry hardware has now demonstrated the concept of dual-mode operation.

In FY 1984, the powered-lift research and technology effort will initiate wind-tunnel model testing with new propulsion simulators to provide a more realistic simulation of aerodynamic/propulsion interference effects. Wind-tunnel testing will include two single engine STOVL fighter models to define the aerodynamic performance characteristics.

Flight dynamic activities will emphasize three areas of concern to future tactical military aircraft: analyses of nonlinear high altitude, high angle-of-attack flight characteristics, stall departure/spin behavior, and improved high angle-of-attack combat maneuverability. Piloted simulation studies of the integration of thrust vectoring with aerodynamic controls and of thrust vectoring throughout the flight envelope will be applied to advanced short-takeoff-and-landing (STOL) and STOVL concepts.

Aerodynamics and propulsion integration research will emphasize STOL and STOVL, sustained supersonic operation, and long range missile concepts. The vectored-thrust two-dimensional nozzle program will include analytical efforts addressing internal aerodynamics, heat transfer and materials, and improved hot section testing capability. It will also include tests on full-scale nozzles.

Advanced controls research will include component technology and subsystem interactions. Digital airframe and engine controls for aircraft with vectored-thrust and reduced stability are also under study.

In the area of supersonic cruise, research will concentrate on configuration development and technology trade-off studies for competitive vehicle concepts. Specific areas of interest include arrow and curved leading edge wing configurations, transonic interference effects and high angle-of-attack performance. Structures technology will remain directed at titanium fabrication concepts for high temperature requirements. Construction will be completed on the variable diameter centerbody inlet wind-tunnel model.

Hypersonic vehicle activities are focusing on two applications with concurrent technology development. For the Mach-5 cruise vehicle with the dual engine propulsion system, research activities include variable geometry inlets, variable geometry nozzles, and hot structures for nacelle construction. Build-up of the hypersonic dual-mode scramjet test module will also begin.

Flight research operations support in FY 1984 will include chase operations, airspeed calibration pacer flights, remotely-piloted research vehicle air drops, and flight crew readiness operations. High-speed wind-tunnel operations will continue to generate extensive experimental data for a range of vehicle configurations with emphasis on high-performance military aircraft.

Subsonic Aircraft Research and Technology

The objectives of the subsonic aircraft research and technology program are to provide a broad base of safety oriented technology and to enhance the data base in subsonic configurations and propulsion-airframe integration. The safety research program is organized into the following major categories: (1) aviation meteorology, (2) aviation operations safety technology, and (3) aircraft systems operating efficiency improvement. Research emphasizes the understanding of aeronautical safety hazards and their consequences, and improving criteria for design of aircraft systems and operating techniques thus leading to a reduction in accidents, loss of life and injuries, and loss of equipment.

In meteorological research, significant progress has been made in characterizing lightning and turbulence associated with severe storms. A specially hardened and highly instrumented F-106 research airplane safely penetrated thunderstorms to obtain measurements of lightning and the production of gases, winds, and turbulence. The test results are providing a basis for establishing design and lightning protection criteria for advanced digital avionics systems and nonmetallic structures. These unique, high quality data are being provided to industry and the Federal Aviation Administration (FAA) for use in design and certification standards establishment, as well as aircraft operating procedures, and for the prediction and avoidance of severe storms. Research is progressing in the development of a computer code for the prediction of severe storms and other meteorological hazards. In-flight remote sensing of hazardous clear air turbulence along with the icing research program has formed the basis for cooperative efforts with the Department of Defense to address the alleviation of icing problems.

Advances were made to increase occupant survivability in post-crash fires by breaking the fire chain through the use of advanced materials. Advanced technology materials, such as fire resistant aircraft seat cushions, interior wall panels, and fuselage windows, were demonstrated in full-scale fuselage fire tests. The development of analytical fire modeling to preduct aircraft fire characteristics is underway. A highly instrumented full-scale transport crash program was initiated with FAA and industry participation to provide actual crash data for the improvement of transport crash survivability. The crash effectiveness of antimisting kerosene fuel will also be determined.

Landing gear systems research includes ongoing efforts on tire and wheel failures and the resulting consequences of loads transmitted to the landing gear on aircraft control. The results of the brake dynamics studies have been incorporated into piloted antiskid braking simulations. Expansion and improvement is underway on the Loads Test Track Facility at the Langley Research Center to better match the aircraft speed and landing systems loads for current and future aircraft weights and speeds.

Propulsion/airframe integration research has initiated wind-tunnel tests to address improved methods for reducing drag associated with engine and nacelle installation. Preliminary wind-tunnel and flight tests to explore the extent and potential for natural laminar flow on a wide range of smaller aircraft have been completed.

In FY 1984 the aviation safety program will focus heavily on severe storms research which will include gaining additional lightning strike data with the F-106. Greater emphasis will be placed on low altitude phenomena such as wind shear, heavy rain effects and vortex detection in the airport area. The controlled full-scale crash of a transport aircraft which will occur in late 1984, will provide the understanding of the effectiveness of anti-misting kerosene additives for crash fire suppression. Additional emphasis will be placed on ensuring the most effective determination and applications of runway friction and braking performance data. In-flight data acquisition in real icing conditions will be the basis for validation of the Lewis Research Center's Icing Research Tunnel results.

In configurations and propulsion/airframe integration, principal efforts in 1984 will be focused on laminar flow around nacelles with both analytical and experimental definition of minimum drag configurations. Natural laminar flow has been demonstrated up to Mach 0.8 and at wing sweep angles exceeding 20 degrees. In 1984 concentration will be on the optimization of wing geometry, airfoils, and surface finish to maximize the extent of laminar flow. Further efforts will also be directed toward analytical prediction and experimental verification of aerodynamic and control system approaches or reducing susceptibility to stalls and spins in light aircraft in a joint NASA/FAA/industry activity.

SYSTEMS TECHNOLOGY PROGRAMS

FISCAL YEAR 1984 FUNDING LEVEL

Materials and structures systems technology	
Propulsion systems technology	
Avionics and flight control systems technology	
Rotorcraft systems technology	$27,600,000
High-performance aircraft systems technology	19,900,000
Subsonic aircraft systems technology	5,000,000
Advanced propulsion systems technology	20,000,000
Numerical aerodynamic simulation	20,000,000
General augmentation for Advanced Transport Operation	14,000,000

System, Laminar Flow Control.
Engine Component Technology and Advanced.
Turbofan Research.

Total	106,500,000

Materials and Structures Systems Technology

The objectives of the materials and structures systems technology program concentrated research efforts in the materials and structures technology areas which have high payoff for application in the design of future aircraft and engine systems.

The integrated program for aerospace vehicle design achieved a major milestone in FY 1982 with the release of an engineering data management software package for evaluation by industry and NASA. This activity is continuing in the computer science and applications research and technology base program.

The aeroelasticity of turbine engines program was successfully concluded in FY 1982. The results have provided a baseline for a study of forced response in the materials and structures research and technology base program in FY 1983 and beyond.

Propulsions Systems Technology (Helicopter Transmission Technology)

The objective of the helicopter transmission technology program was to demonstrate improvements in weight, noise, maintenance, cost and size of helicopter transmissions through application of advanced technology power transfer components. Hybrid traction drives have been tested to gain understanding of the integration of traction and gear components. Conventional drive systems have been tested with advanced gears, bearings, seals and lubrication systems, showing major improvements in power/weight ratio and life expectancy. Technology efforts in this area are continuing in the propulsion systems research and technology program.

Avionics and Flight Control Systems Technology

The avionics and flight control systems technology program had two objectives. The first was to apply fundamental knowledge gained in the research and technology base to demonstrate technology readiness. This was accomplished at the Ames Research Center through the evaluation and improvement of a number of verification and validation tools for digital flight control systems. These tools became the basis of the Federal Aviation Administration's certification procedure for digital flight control systems and were used in the certification of the Boeing 767 aircraft. The second objective was to promote the transfer of advanced systems techniques to the aircraft industry through experimental testing and verification in a realistic enviornment. This was accomplished using NASA's F-8 digital fly-by-wire aircraft. An example of such an accomplishment in FY 1982 was the evaluation of an advanced control law developed by the Royal Aircraft Establishment, and the demonstration of the superiority of that control law over comparable existing control laws. The elements of the avionics and flight control systems technology program applicable to generic research are now being carried out under the aircraft controls and guidance research and technology program in the research and technology base.

Rotocraft Systems Technology

The objective of the rotorcraft systems technology program is to provide ground-based and flight research on integrated systems which hold promise for future military and civil rotorcraft concepts. The program covers the broad technology areas of guidance and navigation; flight research on advanced rotor concepts; tilt rotor systems technology; and rotorcraft technology in specific areas of structural dynamics, noise, aeroelasticity, and propulsion systems. The experimental ground-based and flight testing is closely coupled with collocated Army laboratory efforts and complements the research and technology base program activities.

During the past year, the rotorcraft systems technology program included a number of significant accomplishments. In the guidance and navigation area, research focused on the use of airborne radar for remote site guidance in all-weather operations. A special effort was made to more clearly integrate the activities in this area with the related programs within the FAA. Accomplishments included the flight testing of enhanced weather radar concepts over water, participation in Army millimeter radar flight tests, and initial investigation of image enhancement techniques for on-board guidance displays. Baseline Global Positioning System (GPS) flight tests were conducted to explore system errors as a lead-in to work on differential GPS techniques. Initial studies were done to begin investigation of flight path guidance for noise abatement procedures.

Advanced rotor systems technology activity continued with heavy emphasis on the RSRA operational readiness. The compound configuration achieved full operational status for research flight investigations. The helicopter configuration underwent extensive ground calibration and a subsequent flight loads survey. Extensive in-flight noise data and simultaneous rotor airloads data was acquired from an AH–1G research helicopter flight program. Noise data were also acquired from the new AH–64 helicopter. Preliminary design was initiated for a joint NASA/Army research rotor system to be flown on the RSRA.

The tilt rotor proof-of-concept and military suitability program continued. This joint NASA/Army program utilizes the two XV–15 Tilt Rotor Research Aircraft. One aircraft was used to expand and fully document the flight operational envelope at normal and high gross weight conditions. These flights covered hover, level flight, conversions between hover and high-speed flight, maneuvers, and high altitude test conditions. The second aircraft was utilized in extensive demonstration flights to assess the suitability of the concept for a number of military operational missions including shipboard operations and Nap-of-The-Earth flying.

Advanced rotorcraft technology activity also focused on tasks complementing the research and technology base efforts. A high priority research effort was initiated in response to the increasing need for a valid helicopter noise prediction capability. This research is to be carried out in a joint program with the United States helicopter manufacturers so that the combined resources from NASA and industry can be focused on the development of reliable noise prediction methodology. A major accomplishment was achieved in the development of a finite element computer program and associated CH-47 shake test data acquisition in preparation for a comparison of the predicted and measured dynamic response of a large helicopter airframe. Another milestone was achieved in the convertible engine systems technology area with the successful completion of the TF-34 engine modification design review and the initiation of hardware fabrication in preparation for ground testing.

The rotorcraft guidance and navigation activity will emphasize remote site all-weather operations by conducting a series of simulations to explore high resolution radar application for zero-zero landings. Simulations will also focus on implementation of differential GPS concepts prior to flight investigation. Noise abatement flight path guidance will also be explored in simulation to assess the potential benefits of various concepts.

RSRA/rotor systems research will emphasize advanced configuration assessments of a modern four-bladed rotor and preliminary design of an advanced flight research rotor to be tested on the RSRA. Available airloads data from the AH-1G flight program will be analyzed and correlated with available theory and will be used as input to existing noise prediction programs for correlation with measured noise data. Final checkout will be achieved on the RSRA electronic flight control system in preparation for extended flight research activities. Analysis will be completed on data from the static calibration of the active isolation/balance system on the RSRA and simulation of RSRA flight test conditions will be carried out with the new RSRA interchangeable cab with integrated visual systems in order to verify the airworthiness of the research systems.

Advanced rotorcraft technology will focus on initial ground testing of the composite tilt rotor blades. Rotor noise tests will be conducted in small-scale and large-scale to continue research aimed at developing reliable prediction methodology for rotor systems. Structural dynamics research will emphasize the application of optimization techniques to large finite element analyses for the prediction of helicopter airframe vibration levels. Ground tests will begin to establish a data base for convertible engine concepts utilizing the TF-34 engine and research control system.

In order to advance the state of technology on vehicle concepts, an increased effort in advanced tilt rotor technology will be undertaken in the technology for next generation rotorcraft program with emphasis on exploring the means of improving the speed, range, and flying qualities of the tilt rotor class of vehicle. Advanced structural, aerodynamic, propulsion, and control concepts will be investigated. In addition, in a joint program with the Defense Advanced Research Project Agency an RSRA vehicle will be modified to accept and flight test an X-Wing rotor system. The primary area of interest here is in the utilization of the RSRA unique capabilities to explore the start-stop phase of flight for the X-Wing concept in the speed range of 200 to 300 knots.

High Performance Aircraft Systems Technology

The objective of the high-performance aircraft systems technology program is to generate validated engineering methods and design data applicable to the development of advanced high-performance, high-speed aircraft for military and civil applications. The program objective is accomplished by analysis, ground-based simulations, and wind tunnel experimental research and flight research tests of aircraft as well as development of specific analytical methods for turbine engine durability improvements.

In FY 1982, research began on an integrated digital flight controls/fire control system for an F-16 aircraft as part of a joint NASA/Air Force Advanced Fighter Technology Integration (AFTI) project. In another part of this joint AFTI effort, research on the variable camber mission-adaptive wing concept proceeded with the modifications and instrumentation of the F-111 aircraft on which the flight research will be performed. An extensive evaluation of a NASA conceived aileron-to-rudder interconnect control system on an F-14 aircraft is in the concluding phase of a joint NASA/Navy program to improve high angle-of-attack flight characteristics. Significant propulsion system performance and reliability improvements were flight validated by NASA pilots using an F-100 engine powering an F-15 airplane equipped with a digital electronic engine control in a cooperative NASA/Air Force project. In FY 1983 NASA will continue propulsion system improvement flight investigations using the F-15 with an F-100 engine model derivative. Also, during FY 1983, the joint NASA/Defense Advanced Research Projects Agency (DARPA X-29A forward swept wing flight demonstration program will be conducting extensive NASA wind-tunnel tests, computational analysis, and ground tests in preparation for flight tests beginning in FY 1984.

Design maneuvering and performance points were successfully demonstrated in flight during this year with the highly maneuverable aircraft technology (HiMAT) vehicles. As a result, final assessment is underway to evaluate the benefits of the new technologies in HiMAT applicable to future fighter aircraft. These include aeroelastically-tailored graphite-composite wing/canard structures, closely-coupled wing/canard design configurations, and digital flight control systems integrated with greatly reduced vehicle static stability to achieve lower weight and greater maneuverability.

In FY 1983, the turbine engine hot section technology (HOST) program is addressing engine durability with the following developments: a heat transfer computer program will be completed and delivered; a thermodynamic engine model code will be developed; test hardware for large-scale thermal radiation testing will be fabricated; a computer program for dilution jet modeling will be completed; a predictive technique for impingement cooling will be developed; data will be obtained for film cooling effects on boundary layer transition and heat transfer, as well as mapping the duct flow itself; oxidation modeling for a promising surface coating will be completed; and, various instruments, including dynamic gas temperature sensors, flow viewing systems and a heat flux sensor, will be completed and testing begun.

The FY 1984 funding level reflects an increased emphasis on high-performance flight research to provide the technology foundation applicable to the development of future high-speed aircraft. The high-performance flight research activity in FY 1984 will involve a variety of high-performance aircraft to investigate advanced concepts. Several projects will enter the flight test phase during this period. Under the joint NASA/Air Force AFTI projects, the F-16 airplane will begin flight evaluations of integrated technologies comprising an automatic maneuvering and attack system, and the F-111 will commence flight envelope expansion and preliminary performance assessment with the mission adaptive wing. The joint NASA/DARPA X-29A forward swept wing flight demonstration program will begin the proof-of-concept flight test phase. This program continues development and validation of advanced aeronautical technologies assessed under the recently completed HiMAT program. A flight program will also be initiated with an F-16 aircraft to demonstrate a concept for a novel external stores pylon design, which will isolate or decouple pylon stores dynamics effects from airplane wing flutter modes, to enable maximum utilization of the fighter aircraft flight envelope when carrying external stores.

The increase in HOST funding is for the planned expansion of the HOST research effort. The research will concentrate on turbine flow visualization and three-dimensional heat transfer modeling along with the expansion of the effort in thermo-mechanical/structural analysis. Studies will be initiated on life prediction of coatings. The research program on the use of ceramic materials for long life turbine engine components will be emphasized.

Subsonic Aircraft Systems Technology

The objective of the subsonic aircraft systems technology program is to provide a substantiated base of key technologies, design data and validated design procedures. Individual concepts are examined in the systems context with other interacting components and technologies to define techniques and procedures for obtaining maximum benefit from these applications.

The objective of the energy efficient transport program has been to provide aerodynamic and active control technology for improved efficiency in transport aircraft. Flight tests of an advanced pitch augmentation system permitting flight with large unstable margins were completed under the FY 1983 program. Also, fabrication of a flight test version of a multi-axis active flight control system was initiated.

The objective of the laminar flow control program has been to provide a proven technology base for the practical achievement of laminar flow under operational flight conditions. During FY 1983, the first wind-tunnel tests of an optimized laminar flow control airfoil showed extremely large reductions in drag. Equipment modifications to permit potential flight tests of leading edge sections of laminar flow systems are being continued in FY 1983 and are on schedule for an early 1984 flight.

The objective of the advanced transport operating systems program has been to provide system and procedural technology for enhanced interfacing of the aircraft and the air traffic control system. The FY 1983 activity includes the following: a major flight activity to develop basic criteria for Microwave Landing System approaches, begun in FY 1982, will be completed in FY 1983; components for major refurbishment and update of the B-737 flight facility are being procured in FY 1983; and the advanced crew station simulator design will be completed in FY 1983.

The objective of the composite primary aircraft structures program has been to provide a technology base for graphite composite material used in secondary and medium primary aircraft structures. Current composite technology efforts are proceeding on schedule and major milestones are being met on lightly loaded, stiffness critical, secondary and medium primary structures. Secondary composite structures are now state-of-the-art and already in airline operational service on the B-767. The FAA certified the B-737 composite horizontal stabilizer medium primry structure in August 1982, and five shipsets of this component will be installed on the product line and will enter flight service evaluation in 1983. The L-1011 vertical stabilizer successfully completed all strength and damage tolerance tests, and small scale elements are approaching 20 years of simulated environment and fatigue testing. Ground tests of the DC-10 vertical stabilizer are in progress and, in addition to the DC-10 flights of this vertical stabilizer, the USAF has indicated interest in installing a similar stabilizer on the KC-10. The program on medium primary structures will be completed with the FY 1983 FAA certification of the DC-10 vertical fin.

The objective of the advanced composite structures technology program is to develop a composite primary airframe structures technology base that achieves the full potential of weight, fuel, and cost savings possible for the design of civil and military transport aircraft in the 1990's. The program's purpose is to establish a composite engineering data base which will permit government and industry management decisions to commit composites to advanced, large aircraft with acceptable cost and risk. Full airframe use of such lighter weight composites can reduce overll aircraft weight and acquisition costs by up to 15 percent, significantly lowering operational costs and extending service usage.

Funding is not included in fiscal year 1984 for continuation of the laminar flow control, composite primary aircraft structures, energy efficient transport or advanced transport operating systems programs.

The fiscal year 1984 budget estimate for the advanced composite structures technology program is based on consideration of the existing state-of-the-art for composite structures and the technology needed to establish the engineering data and confidence required for the application of composite primary stuctures to large civil and military transport aircraft in the 1990's. This research and technology effort will be initiated in three major areas: (1) wing technology development focused on critical design issues, structural criteria, and certification requirements, (2) fuselage curved panel technology considering biaxial and post-buckled loading, and (3) advanced materials with increased resistence to damage and impact loads. These efforts will provide a basic understanding of composite performance in large airframe structures, and provide design guidance in the development of acceptable configurations and procedures to evaluate limiting structural effects.

In fiscal year 1984, wing structure activity will include the completion of a preliminary design, the establishment of structural configurations, and the initiation of small scale tests. Analytical procedures will be determined and structural criteria defined for thick laminates, fuel containment, and damage tolerance. This research will begin to provide the design engineering data and criteria needed to support future designs of large, heavily loaded composite wings structures.

Technology development for fuselage structures in fiscal year 1984 will focus on establishing design concepts, identifying critical design issues, and determining damage resistant configurations. Additional work will define limits of post-buckling behavior and will extend to larger curved panels under combined pressure and bending loads. These efforts will provide design approaches and engineering data on strength critical, large curved panels and establish design methods and criteria for large, thin pressure sections.

Advanced materials research and technology will concentrate on tougher, more processable systems with increased resistance to flaws and induced damage. New resins will be synthesized to increase strain limits, and the fiber interface will be studied to improve bonding characteristics.

Advanced Propulsion Systems Technology

The objective of the advanced propulsion systems technology program is to achieve improved performance, lower fuel consumption and reduced noise and emissions in future aircraft engines through the integration of improved propulsion components.

The energy efficient engine program will be completed as scheduled in FY 1983. The final component development and integration phase of the energy efficient engine program will be completed in 1983. The gas generator core test program was successfully conducted, and the integrated core/low spool test is scheduled for the second quarter of FY 1983. The high presure turbine was run successfully in a warm air rig and further testing of the high pressure compressor is to be completed in 1983. The data continue to support the goal of 15 percent fuel savings with application of these technologies in advanced turbofan engines.

The advanced turboprop systems program achieved encouraging results in 1982 in the areas of installation drag reduction and noise prediction. Wind-tunnel tests of powered scale-model propfans in an under-the-wing installation on modified wings yielded better than predicted drag reductions. Flight tests of scale-model propfans obtained far-field noise measurements that were lower than analytically predicted. Design and fabrication of large scale (9-foot diameter) propfan blades began in 1983, along with the subscale aeroelastic model of the large-scale propeller. Analytical methods for the design of efficient, low-noise, flutter-free propfan blades are being upgraded and verified. Results obtained to date have increased the potential of achieving 15–20 percent fuel savings relative to an equally advanced turbofan for a variety of civil and military aircraft applications in the Mach 0.7–0.8 cruise regime.

The general aviation/commuter engine technology effort in 1983 is an expansion of samll engine component research that is aimed at improving small engine component efficiencies to the levels achieved in large engines. Specifically, analytical design techniques that incorporate the small engine limitations associated with scale, surface finish and Reynolds number will be developed and verified through the use of advanced instrumentation and experimental techniques.

Broad property fuels research within the research and technology base has consisted of research on the physical and combustion properties of future avaition fuels. In 1983 the systems technology program will provide increased emphasis on sub-elements of combustion systems, turbines and fuel systems in order to understand the effects of fuel property variations. The objective is to provide the understanding which will lead to fuel flexible concepts, components, and systems to help aviation adapt to evolving world energy supplies.

During FY 1984 advanced turbofan technology activity will continue as will further work on broad property fuels and general aviation/commuter engine technology. Advanced turboprop program activities will continue with long-lead design activities in support of a systems integration/flight research test in 1987 to determine large-scale advanced turboprop feasibility.

Numerical Aerodynamic Simulation

The objective of this initiative is to significantly augment the Nation's program in computational fluid dynamics and other areas of computational physics by developing a preeminent capability for numerical aerodynamic simulation. This program will provide new computational capabilities to allow solutions of problems which are currently intractable. The ongoing research in computational aerodynamics will be augmented to provide a pathfinding role in aeronautical research, allowing solutions of the full Navier-Stokes equations, providing first-principle prediction of the viscous flow about simple aeronautical shapes, and enabling the prediction of performance of complete aircraft. These results will provide the opportunity to understand the underlying mechanics of turbulence as well as flow separation and reattachment, leading to new concepts for low-drag aircraft and more efficient engines to assure future U.S. aerospace superiority. In addition to basic research, NAS will also play an important future role in preliminary design, configuration refinement and design verification by permitting the accurate prediction of aerodynamic performance, thereby improving the productivity of the research and development process. The program will permit the solution of viscous compressible three-dimensional fluid equations of motion that govern the areodynamic flow over aircraft and missiles and within components of turbomachines such as compressors and turbine blades and engine inlets and exhaust nozzles. The computational capability will evolve as advanced prototype commercial hardware becomes available, beginning with a computational speed of about 0.3 billion floating point operations per second (GFLOPS) in 1984, increasing to 1 GFLOPS (sustained) and 240 million words of high-speed memory in 1987 and continuing to advance thereafter. It will provide modern and efficient access to about a hundred users nationwide for applications to computational aerodynamics, computational chemistry, and structural analysis as well as other complex analytical problems. Following extensive systems analyses both in-house and under contract, a flexible plan has been prepared for the design and procurement of the system components with phased updates of a commercially available high-speed processor. Simulation studies are being prepared to establish design criteria and provide validation of the new high bandwidth satellite networking system.

Numerical Aerodynamic Simulation is expected to provide important breakthroughs in basic research leading to new understanding of fluid flows, such as the mechanisms of the initiation, propagation, and potential control of turbulence; the ability to calculate internal flows through the complex passages of turbine engines; and the computational power to analytically predict the performance of complete aircraft. NAS pathfinding research will also become increasingly important in the aircraft and turbine engine design process.

First year funding will provide for the cost of an initial high-speed processor with a speed of 0.3 GFLOPS. In addition, procurement of peripheral hardware to serve several generations of high-speed processors will be started and the user-friendly operating system will be evaluated and further developed to meet the needs of succeeding phases of the program. Previously funded studies of cost and technology readiness provide for high confidence in the estimates.

A flexible plan has been prepared for the design and procurement of the system components. In addition to providing the initial high-speed processor (0.3 GFLOPS), the first year funding will enable considerable progress toward the implementation and testing of a user-friendly peripheral system which will serve several generations of high-speed processors and provide for extensive simulations to verify the succeeding phases of the project.

9. SPACE RESEARCH AND TECHNOLOGY, $143,000,000

FISCAL YEAR 1984 FUNDING LEVEL

Research and technology base	$131,200,000
Systems technology programs	7,200,000
Standards and practices	4,600,000
Total	143,000,000

The overall objective of the space research and technology program is to advance the technology base in support of NASA's role as an effective, productive, and long-term contributor to the continued preeminence of the Nation in space. A timely investment in research and technology is essential to support and promote rapidly expanding civil, military, and commercial space interests. In planning the space technology program, the Office of Aeronautics and Space Technology (OAST) consults extensively with other NASA program offices, the Department of Defense, and industry in order to identify and anticipate technology needs. Systems analyses and trade-off studies are also conducted to identify high payoff technologies that will enable future space missions. Research and technology development evolves from concept to laboratory, then to proof-of-concept testing on ground or in space and eventually to program application, in a long-term process of incremental progress along both planned and unexpected opportunity paths.

The space research and technology program is committed to: (1) providing a base of proven technology supporting future national programs in the conception and design of advanced spacecraft; (2) continuing development of the technology foundation for improving low-cost access to space through Shuttle enhancements and orbital transfer concepts; (3) supporting activities related to a more permanent human presence in space by focusing technology; (4) supporting the projected long-term needs of military and commercial use of space.

The FY 1983 estimate remains the same in total, although a minor adjustment has been made between the two major program elements.

Within the space research and technology base, an internal program rebalancing was executed in order to place increased emphasis on continuing priority programs including controls, human factors, and crew and life support technology. This realignment of resources, with a net reduction of $0.5 million, was accomplished by instituting modest reductions in the level of effort planned in FY 1983 on a wide range of research and technology base disciplines and programs.

In the systems technology area, the $0.5 million increase in funding reflects a programmatic decision to place additional emphasis on high priority Spacelab payloads flight experiment activity in FY 1983.

The FY 1984 research and technology program will be directed toward maintaining a strong research and technology base within the discipline areas of fluid and thermal physics, materials and structures, computer science and electronics, communications and data systems, space energy conversion, controls and human factors, and chemical propulsion. While a portion of the disciplinary program will be directed toward broadly generic or basic goals, many of the program elements provide extended and often enabling capabilities for each of three classes of space systems: spacecraft, space transportation, and space station.

The following high priority technology goals have been emphasized to identify and develop technology options to meet advanced requirements for these future space systems: provide new materials and concepts for orbiter thermal protection; advance the technologies to enable longer-life, reusable engines; provide the technology for orbital transfer vehicle propulsion and tankage; evolve the capability for high capacity electrical power generation, storage, and distribution systems; provide the technology of satellite communications through research in electronic components, space and ground systems, and propagation phenomena; develop enabling technology for large deployable RF antenna systems; generate the technology base for teleoperator and autonomous space systems; improve space information management through smart sensors, onboard data processors, software, systems architecture, and ground systems, generate the technology base in compute science for aerospace applications; develop computational fluid dynamics techniques for application to entry body and rocket engine design; advance the technologies to fully support and exploit human capabilities in space; establish feasibility of advanced sensor concepts; and advance the technology of distributed, adaptive controls for large space systems. Systems-level studies conducted within the research and technology base will continue to focus the discipline and system research and technology activities in directions which will lead to maximum benefits from available resources.

RESEARCH AND TECHNOLOGY BASE

FISCAL YEAR 1984 FUNDING LEVEL

Fluid and thermal physics research and technology	$8,800,000
Materials and structures research and technology	15,700,000
Computer science and electronics research and technology	16,300,000
Space energy conversion research and technology	18,000,000
Multidisciplinary research	1,000,000
Controls and human factors research and technology	7,600,000
Space data and communication research and technology	19,300,000
Chemical propulsion research and technology	18,200,000
Spacecraft systems research and technology	3,700,000
Transportation systems research and technology	8,000,000
Platform systems research and technology	12,100,000
University instrumentation	2,500,000
Total	131,200,000

Fluid and Thermal Physics Research and Technology

The objectives of the fluid and thermal physics research and technology program are to: (1) develop validated, experimental and computational techniques for predicting flowfields for a broad range of arbitrary aerospace vehicle configurations; (2) improve techniques for predicting aerodynamic and aerothermodynamic characteristics of vehicle concepts in the continuum-to-rarefield flow regimes; and (3) provide the experimental technology required for aerodynamic and aerothermodynamic testing. Improved techniques for predicting the capability and response of future aerospace vehicles in the various flow regimes, including ascent to orbit, low-earth orbit, and entry, will provide increased confidence needed for maximum use of the performance and payload potential of those systems.

The aerothermodynamic heat-shield analysis for the Galileo probe has been completed, and entry gas dynamics research has been redirected toward studies of vehicle flowfields in the continuum-through-rarefield portions of the Earth's atmosphere. Initial flowfield analyses have been conducted on several future transportation concepts designed to use high-altitiude aero-assist techniques in order to minimize propulsion system requirements. Analyses of the aerodynamic and aerothermodynamic characteristics of aeroassisted orbital-transfer and earth-to-orbit vehicle concepts, plus preliminary studies of aero-maneuvering orbit-on-demand vehicle concepts, are in progress.

Since continuum theory is invalid in transitional and rarefied flow, a probabilistic treatment of fundamental Newtonian theory has been developed to provide benchmark predictions of the orbiter jet-thruster flowfield patterns in low-earth orbit. This technique is being extended to predict the drag of space platform configurations, plume flowfields and contamination patterns, and flowfield interactions for rendezvousing vehicles in low-earth orbit.

Current orbiter instrumentation and orbiter experiments are providing the important research-quality flight data needed to evaluate and improve athe computational and ground-based experimental methods. Analyses of the flight data have provided new information on the entry environment, flow transition, surface catalysis, tile-gap heating, and other important phenomena. In addition, unexpected orbiter aerodynamic performance spurred a reevaluation of the prediction methods for control-surface effectiveness in both the transonic and hypersonic speed regimes.

An important new area of emphasis is characterizing and quantifying the aerothermal loads caused by flow interactions with typical surface irregularities of thermostructural systems. A data base is being developed at simulated, high-energy entry conditions through benchmark experiments on large- to full-scale surface gaps, bowed surfaces, protuberances, fuselage-wing junctions, wing-elevon coves, and other surface irregularities. These benchmark data are being used to validate three-dimensional flowfield computational predictions of peak-heating and pressure-loading magnitudes and locations for complex aerospace configurations.

In FY 1984, the research program will emphasize expanding the experimental data base for improved aerospace vehicle design capability and, also, for development and application of experimentally-validated computational flowfield prediction techniques. These efforts will be focused on improving future space transportation systems by providing the aerodynamic and aerothermodynamic technology to support more efficient thermostructural systems, enhanced overall aerodynamic performance with emphasis on high-altitude maneuvering capability, and increased engine lifetimes through internal aerothermodynamic performance.

Orbit-on-demand vehicles will require substantial improvements in design over current space transportation systems, including: significantly improved propulsion capability; advanced and reusable thermostructural systems; and sophisticated maneuvering capability throughout the atmosphere. The program will focus on developing the aerodynamic and aerothermodynamic performance capability to meet these requirements for a control-configured space transportation system design concept having rapid response, limited payload capability, and operational flexibility.

Aerodynamic performance and heat transfer requirements will be experimentally evaluated for aeroassisted orbital transfer vehicle concepts with varying lift-to-drag ratios. In addition, three-dimensional flowfield computational techniques will be developed and evaluated in order to assess thermal protection system requirements and control surface effectiveness through the predicted trajectories.

The research program will also be directed toward prediction techniques for computing the drag of space platforms in low-earth orbit, initially including component shadowing effects for simple configurations and subsequently including complete, complex configurations. The Monte Carlo technique will be used to perform a probabilistic analysis of the molecular interactions in the very rarefied environment at orbital altitudes. This same technique will also be applied, for benchmark cases, to prediction of the flowfield patterns produced by the Space Shuttle propulsion system plumes and their interaction during rendezvous with a space platform.

Materials and Structures Research and Technology

The objectives of the materials and structures research and technology program are to provide the performance, efficiency, durability, and economy required for large area space structures, antennas and space platforms, advanced space transportation systems, orbiting spacecraft, planetary probes, and Shuttle payloads. Major technical areas of emphasis in materials include basic understanding of advanced materials; development of computational chemistry methodolgy; characterization and understanding of long duration environmental effects of space on materials; and development of ceramic, metallic, and advanced carbon-carbon thermal protection systems. Structures technology is directed toward development of advanced truss structural concepts, reliable methods for deployment/erection of space structures, new concepts for advanced Shuttle and orbital transfer vehicles, and efficient analytical methods for design and evaluation of advanced space structures. Research includes the development of Shuttle payload dynamics and acoustic analysis methods, integrated structures/thermal/controls analysis and optimization techniques, and efficient methods for nonlinear structural analysis.

During the past year the mechanisms and kinetics of the chemical reactions that occur during the cure of epoxy composites were determined, greatly expediting development of techniques to control the processing and production of uniform, high quality composites. Another major achievement was the invention of a fastener for joning carbon-carbon components in a hot structure which accommodates differential thermal expansion without generating high failure level stresses in either component. Computation fluid dynamics techniques were used for the first time to describe aerothermal loads and pressure, and heating distribution over the surface of thermal protection systems. This capability provides a basis for future protuberance work. With the completion of the Space Environmental Effects Facility, it is now possible to expose candidate materials to all of the space environmental factors at the same time, thus identifying and characterizing synergistic effects. A continuous 400 hour run has demonstrated that there are differences in effects due to radiation dosage rates. Using data recorded in the first three Shuttle orbiter flights, acoustic model predictions have been validated with actual payload bay flight measurements. A computer model has been developed that provides for simultaneous optimization of the trajectory, the structure, and the thermal protection system of a reusable space vehicle to minimize the total weight of the system. A segment of a Shuttle aft body flap made of graphite polyimide has successfully passed all mechanical, thermal, and acoustic tests required for qualification for space flight. Furthermore, the feasibility of directly bonding thermal protection tile to a structure has been demonstrated in simulated flight tests. The combination of the two achievements provides a new structural option for lighter weight space transportation vehicles. The reduction of $2.1 million primarily reflects a reduction in research on space durable materials, advanced thermal protection systems, advanced space structures, and materials science. These funds were realigned within the space research and technology base in order to support increased program activities in the areas of controls, human factors, and crew and life support research.

A major research effort is directed at determining the durability of polymeric materials in space, including structural composites, thermal control coatings, films, adhesives, and seals. The emphasis is on identification of damage mechanisms and the development of methodology for accelerated tests to predict long-term performance. Research will focus on identifying stress and developing structural materials that fulfill dimensional stability requirements of large space antennas and space stations. Basic research in the fundamentals of tribology (friction and wear) of bearing systems and long-life space environment lubricants and seals will focus on providing the technology for advances in future space transportation systems. Although intermetallic compounds are presently very brittle, research will be directed toward solutions in order to realize significant performance advantages in advanced turbopumps for the Space Shuttle main engine (SSME). Thermal protection concepts and materials will be evaluated for the protection of reentry vehicles. A better understanding of fundamental material surface behavior through the applications of computational chemistry will continue to be a focus in the program.

In FY 1984, research on truss stuctural concepts for deployable and erectable space systems and the identification of design and qualification procedures required to meet possible future mission requirements will be completed and evaluation procedures initiated. Simultaneous and sequential deployment concepts will be evaluated and tested for potential application to space station configurations. In the area of integrated analysis and synthesis methods, emphasis will be on improved thermostructural modeling and analysis methods to include thermal radiation and convection effects on structural response. Also, reserarch will focus on the development of optimization methods applicable to space vehicle design for lightest weight and/or cost.

Both analytical and experimental research will be conducted on non-linear behavior of very flexible structures including definition of the interaction between structures, sensors, and controls; active and passive damping effects; and integrated thermal-structural analysis. Payload analysis methods will focus on the adaptation of predictive methods to include coupled Shuttle loads and vibroacoustic response.

The high temperature structures effort will stress the development of the enabling technology for thermal management including research and testing on metallic and advanced carbon-carbon structures for Earth entry vehicles.

Computer Science and Electronics Research and Technology

The objective of the computer science and electronics program is to provide advanced concepts, techniques, system architectures, hardware components, algorithms, and software for space information systems. The program contains disciplinary activities in: electronics, sensor systems, computer science, and automation. Research in electronics is directed at new lasing media and detection methods, and developing new concepts in optical and solid-state technology. Sensor research is focused on extending the capabilities of active and passive sensor systems in terms of spectral range, sensitivity, and resolution. The computer science discipline strives to improve fundamental knowledge of computing principles and advance the state of computational technology in aerospace applications such as fault-tolerant architectures and very high speed processing. Automation research will develop the theoretical and technological base needed to increase the productivity and effectiveness of future operations in space.

In electronics research, advances have been made in ultraviolet excimer lasers and superconducting insulating-superconducting devices for new applications to sense the submillimeter portion of the electromagnetic spectrum. New electronic devices that may have revolutionary solid state properties are being experimentally fabricated by means of a technique called molecular beam epitaxy (MBE). The MBE technique allows new electronic devices to be fabricated from single molecule layers. The microscopic properties of the silicon-silicon dioxide interface, and its role in the degradation of device properties subject to space radiation effects has been connected to the angle of the silicon-oxygen band near and at the interface. The effect of this angle on the fabrication process is currently under investigation.

The sensors research program completed fabrication and successfully tested a proof-of-concept model of a 3x3 X-ray imaging array detector. In support of future NASA low-temperature sensor applications, a mechanical cryogenic cooler has been successfully tested with a 5-watt cooling load and a temperature of 70°K. The design of a slot-array antenna for employment in a multi-frequency, multi-polarization synthetic aperture radar system has been completed, and a submillimeter gas wave laser pumped by a CO_2 laser with a unique folded optical system has shown preliminary success in actual observation of galactic environments from a ground-based telescope.

The computer science research program is being initiated in FY 1983. The resulting program focuses on three theme areas: concurrent processing; highly reliable, cost-effective cumputing; and scientific information management. Concurrent processing research is addressing system architectures and algorithms for computationally-intensive problems in aerospace research, such as computational fluid dynamics and image processing. Research on highly reliable, cost-effective computing is focusing on the technology underlying the construction of systems for long-duration unattended space missions and man-rated flight vehicles. The emphasis is on investigations of fault-tolerant hardware architectures and cost-effective tools and techniques for developing verifiably correct software. NASA is presently accumulating approximately ten billion words of scientific space-derived data per day, with expectations of a hundred-fold growth over the next decade. Research is required for the management and distribution of these data to an active scientific community.

In automation research, a computer program called DEVISER was successfully demonstrated in the laboratory to automatically plan and sequence Voyager spacecraft operations during a simulated encounter with Jupiter. The Voyager and Galileo projects have since committed to use DEVISER operationally for science observation planning. The initial version of a Teleoperator and Robotics System Simulator (TRSS) became operational and a study of display and control modes with varying sensor feedback time delays was completed. Research in real-time computer vision for robot control produced a breadboard system capable of tracking three-dimensional objects at a rate of 3 Hertz.

The electronics research and technology program will continue to explore and develop new data and signal processing techniques employing new and different physical mechanisms. Feasibility demonstrations of advanced optical processing devices will be conducted including the liquid crystal light valve and integrated acoustic-optical receivers for applications to real-time smart sensors and synthetic aperture radar processing.

The sensor systems research and technology will focus on the development of components for submillimeter frequency region of the electromagnetic spectrum, with emphasis on mixers, local oscillators, and meshes. Large arrays using extrinsic silicon for astronomical purposes will be pursued while work on large silicon-charge-coupled device (Si-CCD) format arrays will be completed. The technology demonstration model of a mechanical-magnetic bearing Stirling cooler will be initiated. Work will also continue on the experimental demonstration of the Joule-Thomson refrigerator with loads of up to 1 watt at temperatures around 20°K.

The computer science research program will continue expanding its efforts in software verification and validation technology for highly reliable systems and will evaluate techniques for managing complexity in large scale systems. Research in concurrent processing will be initiated, including work in system architectures for parallel processing, algorithm characterization techniques, an evaluation of programming languages which facilitate concurrency, and a characterization and evaluation of resource management techniques appropriate for operating systems of concurrent machines. The specification of a prototype heterogeneous data base management architecture will be completed which will enable NASA space data users to access any data base independent of its physical distribution and specific organization. Circuit design principles and techniques will be developed for the verification of the fault tolerance and self-checking properties of fault-tolerant large-scale and very large-scale integrated (LSI and VLSI) devices. VLSI devices will be fabricated and experimentally evaluated to test theoretical approaches and predicted results.

In 1984, automation research will demonstrate the replacement of spacecraft controllers by expert systems. The design of an automated environmental control and life support system for space applications will be completed. Robotic vision will demonstrate the capability to track objects composed of curved surfaces moving through a visually cluttered scene. The robotic simulation system will include adaptive control of multiple link arms, multiple sensory modes including vision and force, and artificial intelligence capabilities for planning and executing robot activities.

Space and Energy Conversion Research and Technology

The objectives of this research and technology program are: (1) to increase the performance, extend the operating environment, and decrease the cost of space electric power generation and energy storage subsystems; (2) to make the management and distribution of high levels of power in space cost-effective, autonomous and reliable; and (3) to enhance the performance of electric thrusters to provide a unique national capability in electric propulsion.

Power and electric thruster technologies are critical to, and will enable the large-scale utilization and exploration of space. In FY 1982, significant advances were made in a number of technology areas. A hydrogen-oxygen regenerative fuel cell technology demonstration breadboard has been assembled. An advanced, high capacity bipolar nickel-hydrogen battery concept has been successfully demonstrated. Both technologies enable high power space missions. Progress was made in understanding the chemistry of the lithium-thionyl chloride battery which is essential to its safe operation. In the photovoltaics program a potentially low-cost, high-performance nine-unit miniature Cassegranian concentrator was fabricated. In support of this activity, a miniature laboratory type gallium arsenide solar cell was demonstrated at an efficiency greater than 20 percent. A concept for increasing solar cell performance by changing incoming sunlight to a low-temperature radiation source was tested in initial laboratory configuration and an advanced concept for converting sunlight to electricity using the wave nature of light saw further theoretical development.

Development and testing of components of a power management and distribution breadboard facility continued. Improved components, switches, and circuit designs were also completed. A thermal canister for precisely controlling the temperature of space experiments was successfully demonstrated on the STS-4 Shuttle flight. Activities aimed at providing critical technology elements for a high power, sunlight independent, nuclear reactor power system continued. Poetentially high-performance thermoelectric materials based on boron-carbon and lanthanum-sulfur alloys were synthesized and research continued to establish the promise of an alkali metal-based thermoelectric converter. Studies demonstrated the high potential of a thermal radiator based on a sheet of liquid drops to rid spacecraft of waste heat. In a major advance, two approaches for converting sunlight directly into a laser beam were demonstrated. The first approach converted light into heat which then stimulated the laser action, while the second used heated nitrogen atoms to transfer energy to CO_2 atoms which then produced the laser beam. The ion thruster program demonstrated substantial advancement in increasing the performance of inert gas thrusters. Designs and preliminary tests of high-performance pulsed plasma thrusters were also conducted.

Major emphasis will be placed on evaluating and advancing the technology of both the regenerative hydrogen-oxygen fuel cell and bipolar nickel-hydrogen battery. Such systems are crucial to high capacity space power systems. Efforts will continue toward development of stable, high energy density lithium batteries. Photovaltaic activities will emphasize development of advanced gallium arsenide cells, novel low cost concentrator designs and concepts which may lead to substantially higher efficiencies. Power management and distribution activities will focus on developing improved components, advanced devices and subsystems for high power, high voltage applications such as on a future space station. Also included are rotary joints, high voltage transmission, automation and high voltage power system design guidelines for space plasma environments. Nuclear reactor power system technology will be directed toward identifying and overcoming critical technology limits. Advanced thermoelectric converters will continue to be developed and the feasibility of alternative, high efficiency conversion technologies will be examined. The development of improved heat pipes and thermal radiators will continue along with research directed toward possible conversion and transmission of energy by solar-pumped lasers. In the area of electric propulsion, emphasis will be on increasing thrust per unit of weight, simplification of power processing equipment and further enhancement of thruster efficiency. Systems performance and erosion tests on the magnetoplasmadynamic thruster will also be completed.

Multidisciplinary Research

The objective of the multidisciplinary research program is to conduct long-range, basic research in the engineering and physical sciences focusing on high risk areas with revolutionary high potential payoff for space application and technology. A majority of the research is conducted at universities through the Physics And Chemistry Experiments in Space (PACE) program which supports studies for the design of basic science and engineering experiments that will resolve fundamental scientific questions and discover new phenomena in which conditions of zero or near zero gravity are prerequisite. Some of the studies include experiments on the vibrational modes of liquids, behavior of quantum fluids, combustion, and the dynamics of convection.

The research supported under this activity will be maintained as a broad study of innovative ideas to exploit the unique opportunity of advancing basic knowledge in physics and chemistry through the use of the space environment. The university research conducted formerly under the Fund for Independent Research (FIR) will be conducted as an integral part of the disciplinary research and technology base programs.

Controls and Human Factors Research and Technology

This program consists of two discipline areas, controls and human factors. The goal of the space controls research and technology program is to develop the design concepts and techniques required to enable precise pointing and stabilization of future spacecraft. Emphasis has been placed on developing distributed control concepts for active shape and vibration control, advanced modeling techniques for control system design, and adaptive systems to increase performance. Some recent accomplishments have included advanced theory development for control of distributed systems of complicated structures, and successful demonstration of distributed/adaptive control capability. The first integrated optical circuit chip for a fiber optics gyro has been developed and an advanced video based technique for rendezvous and docking of space systems is under development.

The goal of the human factors program is to develop techniques, data bases and standards for the design and evaluation of man/machine interfaces for use in space operations, including ground control. This program was initiated in FY 1983. Emphasis is on developing technology for man/machine function allocation strategies, teleoperations, extravehicular activity, crew station design and ground control man/machine interface design.

Specific FY 1984 control technology activities will include analytical research on new control concepts, computer simulation of applied control techniques, and experimental investigations to determine the actual performance that can be achieved through new control methods. Continued development of analytical techniques for onboard model error estimation will lead to adaptive controller designs. Advanced component demonstrations will begin on a version of an all-waveguide, integrated optics, fiber-optic gyro. An advanced three-dimensional shape and orientation sensing system which can be used to determine shape and vibration motion of large space structures will be carried to a preliminary design. Advanced space transportation systems guidance and control technology development initiated in FY 1983 will continue with emphasis on greater performance capabilities to reduce uncertainties and associated costs.

In FY 1984, the human factors program will continue developing technology for man/machine function allocation strategies, crew station design, teleoperations, extravehicular activity, and ground control man/machine interface design. A validated data base on the cognitive and behavioral capabilities and limitations of humans in space will be developed in order to provide the basis for an objective methodology for allocating functions to humans and to automation in highly autonomous spacecraft. Man-machine interface design technology will be developed which will enable advanced electronic display and control technology to be optimally used in crew stations, both in spacecraft and in ground control. This will include a technique to evaluate the protocols with which humans interface with crew stations, and a methodology for determining how highly flexible electronic displays should be formatted. Teleoperators design issues to be addressed include computer augmented visual displays and supervisory control systems. Human factors design criteria will be developed for head-up displays (HUD), restraint systems, and powered hand tools for use by astronauts in the extravehicular environment.

Space Data and Communication Research and Technology

The space data and communications program consists of two major areas: data systems an communication systems research and technology.

The overall objective of the data systems program is to provide technology needed to enable more effective transfer of useful data from sensor to user, extraction of information, and exchange of information to permit significant increases in space-derived information at reduced cost. Major sub-elements include data systems concepts, massively parallel processor (MPP), advanced digital synthetic aperture radar processor, onboard data processing, fiber optical data bus and components, ground opticial disk data recorder, magnetic bubble flight experiment, and data base management technology. The MPP will be completed and delivered to the Goddard Space Flight Center in FY 1983. Testing of initial lots of custom integrated circuits for the MPP have been completed, verifying that this unique computer architecture will provide computational speed of up to 6 billion operations per second. A contract for development and delivery of a mass memory assembly with an on-line capacity of 10 trillion bits was awarded. This system will ingest data at rates up to 50 million bits per second and will automatically build catalogs of archived data packets and support on-line browsing by space data users. Delivery is scheduled for 1984.

The objective of the communications technology program is to provide high-performance, reliable, high-risk components and technology needed to insure continued United States preeminence in satellite communications and permit the distribution of processed data from future high rate shuttle payloads, planetary spacecraft, and low-earth orbit and geostationary-orbit platforms. In satellite communications technology, the traveling wave tube (TWT) development effort has produced a new ladder-like circuit called the "tunneladder" which is a potentially inexpensive alternative to conventional TWT's. TWT efficiency has been substantially improved through the use of multistage depressed collectors and materials having low secondary electron emission. In the 30/20 gigahertz (GHz) solid state component area, efforts were initiated to develop a monolithic 20 GHz variable power amplifier and a 20 GHz monolithic phase control transmit module. Two phased-array-fed dual reflector antenna configuration studies were initiated in support of advanced array fed antenna systems for the 1990's. The narrowband communications program completed conceptual designs of an ultrahigh frequency (UHF) feed array assembly as technology options for a future land mobile satellite service. Work has also proceeded to meet the data transfer/communications requirements of future NASA flight programs in the areas of spacecraft frequency sources, power amplifiers, modulators/exciters and low noise receivers.

An optical mass data storage system will be developed which provides 10^{13} bits of on-line storage capacity. New thrusts in on-board fault-tolerant data systems technology for space station will be started, and definition of a high-speed general purpose flight computer program will begin.

In FY 1984, efforts will continue to: advance TWT technology, focus upon multistage depressed collectors constructed from low secondary yield material, and further the understanding of the tunneladder concept. Based upon configuration studies utilizing 30 GHz monolithic receive and 20 GHz monolithic transmit modules, proof-of-concept antenna systems will be designed and evaluated. Efforts to study the critical elements of laser intersatellite links will be initiated. Efforts to complete the feed system for a 15 meter reflector as a technology option for a future land mobile satellite service will be conducted. Activities in communications applicable to a space station such as laser ranging and tracking will be carried out.

Chemical Propulsion Research and Technology

The objective of the chemical propulsion program is to develop technology to improve the life, performance, versatility, and reliability of chemical rocket propulsion systems for future space transportation and spacecraft systems. The program includes efforts directed at reusable propulsion for lower cost operations; high-performance, variable-thrust, and low-thrust propulsion for more mission-responsive vehicles; and efficient, long-life, auxiliary propulsion for precise attitude control and altitude maintenance functions.

Work on advanced, high pressure, oxygen-hydrogen propulsion systems was focused on providing the technology base for upgrading large, high-performance, reusable engines for more efficient Earth-to-orbit vehicles. Because early application of this technology will be utilized to extend the life of Space Shuttle Main Engine (SSME), selection of the initial task was sensitive to SSME technology needs. The design of a hybrid bearing suitable for SSME-class liquid hydrogen turbopumps was complete. The design was based on a similar small-scale version that has been successfully demonstrated in an upper-stage propulsion class turbopump. Testing of more conventional ball bearing designs was initiated using advanced test equipment capable of simulating transient and steady-state loads at high rotational speeds. Statistical life data as a function of loads, design characteristics, cooling and other measurable phenomena is being accumulated.

Technology for advanced upper stage propulsion received increased emphasis in FY 1983. Work on advanced, high-performance, variable-thrust, orbital transfer propulsion has produced several promising conceptual designs. Exploratory technology work to verify the feasibility of each design concept has been initiated. Advanced combustion chamber designs capable of transferring the high heat rates characteristic of these high-chamber pressure engines are being evaluated in hot-gas test rigs utilizing a facility which permits segments of the chamber to be tested in a rapid, low-cost manner. Design concepts for variable flow turbopumps capable of maintaining a high efficiency level over a wide range of flow rates and, thus, thrust levels have been selected.

Technology efforts directed specifically towards high-performance, long-life auxiliary propulsion systems for large spacecraft, such as platforms or space stations, are being initiated. A system analysis effort has been initiated to quantify the technology advances needed.

The effort in advanced high-pressure, oxygen-hydrogen engines will continue to be directed toward developing a better understanding of component operating environments and, through analysis and experimentation, establishing the capability of designing for long life and repeated use. Improved modeling of bearing and seal design, rotor dynamics, structural dynamics, combustion, ignition, and fluid and gas dynamics will enhance future design capability for critical life-limiting components. Special emphasis will be given to developing analytical computer codes that can accurately simulate dynamic loads in hot-gas flow systems in order to predict and extend the life of these hot parts. Advanced nonintrusive sensor designs will be explored; these could provide a significant increase in engine diagnostic and automated inspection and checkout capability. A comprehensive effort in high-temperature materials development and evaluation, as well as advanced fabrication and manufacturing techniques, will support this technology area.

Research in reusable, high-performance oxygen-hydrocarbon propulsion will be continued. The focus will remain on fundamental work in the areas of combustion, stability, heat transfer and cooling. Experimental efforts will be directed toward areas which offer high potential for improved engine performance, reliability, and maintainability. The feasibility of using advanced composite materials for fabricating lightweight engine components will be explored.

Work on variable-thrust orbital transfer propulsion will increase, with emphasis on critical technologies including high-heat transfer combustor wall configurations, highly efficient turbine and pump designs, and advanced high-temperature combustor materials. In low-thrust propulsion, the efforts will continue toward characterizing small combustor performance, cooling and life, and demonstrating efficient hydrodynamic operation of very small pumps. This technology will provide a validated basis for the selection of propulsion system designs to satisfy a broad range of orbital transfer missions.

Auxiliary propulsion technology will be focused on component technology development for a gaseous oxygen-hydrogen system, including small thrusters, gas generators, heat exchangers, pumps and pump drive concepts, and flow control valves.

Spacecraft Systems Research and Technology

The objective of this program is to develop and demonstrate technology for the advanced Earth-orbiting and planetary spacecraft necessary to satisfy planned space missions. Research and technology activities are conducted in those areas where a systems approach is essential to bring individual discipline accomplishments into integrated technology capabilities. The goal is the effective transfer and use of technology in future spacecraft within acceptable levels of risk and cost.

The advanced Earth-orbiting spacecraft technology program includes Earth observation, scientific, and communications spacecraft. Efforts include defining the technology requirements, developing systems concepts, developing advanced analytical tools to aid in spacecraft design, and defining the flight experimental programs to validate broadly applicable technologies that will enable future planned missions.

The technology requirements for a hoop-column microwave radiometer have been defined. Flight experiments to validate antenna system technology are being designed to develop and verify the technology to satisfy these requirements. A first-order kinematics system synthesis and analysis capability, and an integrated RF/structures/controls performance prediction capability are being developed. Systems analysis effort is being conducted to define and assess the technology requirements and options for a 10- to 30-meter Large Deployable Infrared/Submillimeter Reflector (LDR) telescope; this is being followed by a more focused effort to refine selected mirror segment designs and assess their optical, control and structural requirements. A preliminary structures/controls interaction experiment concept has been defined and a detailed design and cost assessment has been initiated. The large solar array dynamics augmentation experiment has been tested and integrated into the Solar Array Flight Experiment (SAFE).

The planetary spacecraft activities are directed toward defining the system-level requirements for the use of aero-capture to increase the weight limits of orbiting spacecraft delivered to planets with atmospheres. Aero-capture is the technique of employing planetary atmospheric braking to remove energy from spacecraft or probes as opposed to the more conventional, but less efficient, technique of applying retropropulsive thrust. A conceptual design of a Titan vehicle aero-capture spacecraft has been completed and system level requirements are being defined.

An effort will be initiated to identify the high leverage technologies for future commercial and military systems. Included are the definition of applicable RF communications, optical communications and precision pointing, Earth observing, satellite payloads and spaceframe technologies.

The development of analytical tools will be expanded primarily for an integrated antenna analysis capability. This capability will allow more efficient analyses of proposed technology options and their resulting impact on system and subsystems performance. The computer-aided design and analysis program capability will be expanded to include controls and integrated propulsion loading effects. The large deployable reflector systems study effort will be continued with a focus on a more detailed assessment of technology options. A major emphasis will be the development of systems simulation tools to enable the assessment of the sensitivity of individual subsystem improvements to overall system effectiveness. This is vital to the prioritization process for the selection of research and technology programs from the extensive candidates available.

Transportation Systems Research and Technology

The objectives of this program are to: identify the technology requirements for advanced trasportation vehiches to satisfy anticipated national needs and integrate these requirements into a comprehensive plan for a supporting technology base; develop technology programs which satisfy these requirements; and support the development, enhancement, and improvement of the space transportation system in areas of recognized technical expertise. These objectives are accomplished through system level studies, analyses, and requirements definition efforts, as well as system and discipline research and technology efforts utilizing ground-based facilities, inspace hardware, and instrumentation which permits the Shuttle orbiter to be used as an advanced research vehicle.

Flight data from both the Orbiter Development Flight Instrumentation (DFI) and the Orbiter Experiments (OEX) have been used to verify preflight predictions of the Shuttle's aerodynamic performance. Prediction methods have been refined and undated with flight data from DFI and OEX. These predictions have been used to certify the orbiter's thermal protection system, to support the expansion of the vehicle's operational envelope, and to support the completion of the STS operational flight test (OFT) program.

Instrumentation developed by the OEX program for determination of the aerodynamic coefficients of the orbiter was flown successfully on all Shuttle flights during FY 1982. Aerodynaminc coefficient instrumentation has also been installed on the second orbiter, Challenger, and will support the certification of challenger beginning with STS–6. OEX instrumentation to measure tile-gap heating and thermal protection system surface catalytic heating properties was flown during FY 1982. Information from the tile gap experiment was also used to investigate anomalies experienced on early Shuttle flights associated with scorching of the gap filler material. Sensors which measure payload environment in the cargo bay were flown during 1982. Data collected is being used to validate structural and acoustic load models to predict payload bay environments. These models will provide design specifications and test environments for satellites and payloads flown in the future.

An effort to identify systems-level requirements for the use of aeroassist to recover reusable orbital transfer vehicles was initiated and programs addressing specific technology issues are being initiated to support a mid-1990's operational vehicle. The post-2000 Shuttle-replacement vehicle study identified new vehicle design approaches that could result in reduced cost and improved performance of future Earth-to-orbit transportation vehicles. Included in these results were the identification of technology for integral tankage concepts to reduce structural weight, vehicle structural and aerodynamics concepts compatible with a decoupled payload bay to increase operational flexibility, and ground and flight opertions approaches which decrease vehicle turnaround time.

Systems analyses efforts will be conducted to define the scope and direction of technical programs needed to reduce the cost and improve the performance of future space transporation vehicles. The computerized conceptual design capability, which has been developed as an important tool for these studies, will be improved. The study to identify systems level requirements for the use of aeroassist to recover orbitial transfer vehicles will be expanded to provide a more detailed definition of vehicle system requirements, identify an optimal aero-braking maneuver, and assess the technology requirements for space-basing. The effort to investigate systems-level requirements of an orbit-on-demand launch vehicle will be completed; the objective is to identify the technology drivers and to develop the technology programs required to accommodate them.

In addition to the aerodynamic coefficient and thermal protection system packages previously described, other instrumentation packages developed under the OEX program will be flown on FY 1984 flights of Orbiter 102. These include low and high altitude research-quality air-data systems, a leeside temperature sensing system, and a more accurate vehicle coefficient determination package. These will be intregated into Orbiter 102 during vehicle modification periods.

An OEX program package to quantify the aerodynamic heating on the windward side of the orbiter during reentry (and thus the validity of the thermal protection system requirements) will be flown in conjunction with some FY 1984 flights. The instrumentation is mounted on the C–141 Kuiper Aircraft Laboratory and produces and infrared image of the orbiter at a selected reentry condition.

Two flight control experiments will be integrated into the orbiter in FY 1984. The first experiment will quantify orbiter handling qualities; the second will provide flight data of an advanced, adaptive autopilot. This data will permit the supporting technology programs to be responsive to actual flight conditions.

Several advanced thermal protection system test panels will be in development for flight opportunities in FY 1984/1985. These panels will provide actual flight data on more durable, higher performance concepts which could become options for retrofit on the current orbiter fleet, as well as candidates for subsequent orbiters. The panels will provide a validated data base for the thermal protection system for advanced post-Shuttle vehicles.

Platform and Systems Research and Technology

The objective of this program is to develop the systems-level research and technology capability which enables future manned and unmanned large space platforms. These research and technology activities require a multidisciplinary approach to meet mission objectives. The technology supports the system and subsystem developments necessary for future space platforms and space stations to satisfy science, technology, applications, and operational mission requirements. Efforts in the areas of systems analysis, operations technology, and subsystem technology are directed toward reducing the cost of station operations and increasing station versatility and performance.

Functional requirements definition of automated unmanned spacecraft are being completed and the techniques will be adapted for determining system-level functional requirements of an inhabited, highly automated space station. The requirements for automating a multi-hundred kilowatt power subsystem are being defined. Software development is being completed for simulation of a teleoperated satellite servicing system. Simulation of distributed control techniques applicable to large space platforms in being initiated. The initial studies of large structure sybsystem interactions are being completed. A technology effort is being initiated for advanced life support systems capable of partial closure of the supply/waste cycle.

For FY 1984, the platform systems research and technology program is grouped into three subprograms: systems analysis, operations technology, and subsystems technology.

The systems analysis effort will evaluate automated and autonomous system concepts, and analytical and experimental verification of space assembly and construction concepts. System-level functional requirements for space station autonomy will be used to determine information system architecture, human-machine partitioning, and automation technology requirements. A ground-based test program for deployable platform and space assembly concepts will be initiated; the results are expected to identify technology requirements which will enable man to efficiently participate in in-space construction, and the required level of automation to accommodate and compensate for his inabilities.

Operations technology includes experimental investigations of teleoperations and robotics through software simulation and hardware validation, and experimental efforts in stabilization and control operations. A hardware/software simulation of remote orbiting systems for the teleoperated servicing of satellites will be conducted. Stabilization and controls efforts will address advanced concepts involving distributed sensors and actuators to enable distributed dynamic control of a space station; the initial effort will be directed at the development of a high-fidelity ground simulation.

Subsystem technology activities will be modestly expanded in FY 1984 to prepare the technology base for a space station capable of cost effective operation and evolutionary growth in size and capability. Some elements of this expanded program are as follows: information sytems research will be expanded to mature advanced data management concepts including adaptive information networks, high-speed data processing, high capacity storage, high-speed communications and transfer, and advanced expert systems for software design.

Human factors research will be conducted to produce advanced concepts, methodologies, and subsystems for habitability and optimal human productivity during long-term space operations. Technology development will include both air and water and environmental control and life support components and subsystems; space human factors and man-machine interaction; and the human interface to intelligent systems.

Advanced auxiliary propulsion technology will be developed to provide high-performance components for control of orbital attitude, drag make-up, and stationkeeping, as well as technology for acquisition, transfer, and long-term storage of requisite fuels.

Attitude control and stabilization technology will include advanced components and algorithms for distributed and adaptive control that accommodate significant changes in station configuration, because of modular growth or deployment, rendezvous, and docking operations. Particular emphasis will be placed on systems identification for *in situ* characterization of time-varying plant dynamics.

Energy management technology will focus on power generation, conversion, and storage, as well as thermal management which includes heat acquisition and transport. Advanced technology for an on-board energy utility system will be investigated as it pertains to high-voltage, high-power components, high-density storage, high-capacity thermal transport, and modular, expandable radiators.

University Instrumentation

NASA's support to universities has declined by approximately one-third over the last decade due to other major program commitments. University instrumentation has declined at even a faster rate. The university community is a critical element of the NASA and U.S. long-range research capability. FY 1984 funding will help to reverse this deteriorating trend by providing funds to universities for the acquisition of modern laboratory equipment in direct support of NASA's goals.

SYSTEMS TECHNOLOGY PROGRAMS

FISCAL YEAR 1984 FUNDING LEVEL

Space flight experiments	$5,500,000
Long duration exposure facility	700,000
Ion auxiliary propulsion system	1,000,000
Total	7,200,000

The objective of the spacecraft systems technology program is to provide the capability to extend ground-based research and technology activities into the space environment using the Space Shuttle, Spacelab, and free-flying vehicles. The space environment uniquely provides the long-term, zero gravity and the actual combination of space vacuum and space radiation environments necessary to the development and characterization of many technologies important to future space systems. This program element encompasses the design, development, integration, and flight test of experiments, and the development of special purpose, reusable, flight research facilities for use in space. These in-space facilities are designed to reduce flight cost for that class of experiments requiring multiple flights.

Current activities include: the development and flight of the Long Duration Exposure Facility (LDEF), a Shuttle-delivered and retrieved 14-foot diameter free-flying experiment carrier; the Ion Auxiliary Propulsion System (IAPS) experiment package to be flown on an Air Force satellite; and, seven discipline technology experiments which are to fly as part of Spacelab or on Shuttle pallets.

The LDEF is currently in preparation for shipment to the Kennedy Space Center for experiment integration and final tests prior to the scheduled FY 1984 launch. The IAPS has been delivered to the contractor for integration with the DOD spacecraft. Integration activities will continue through FY 1983 and a portion of FY 1984. The discipline technology experiments are in various stages of readiness for flights in FY 1984 and FY 1985.

The $0.5 million increase in spacecraft systems technology program funding reflects a redirection of funding from the research and technology base in order to place increased emphasis on high priority Spacelab payloads flight experiment activities in FY 1983. The space technology experiments flown to date on the Space Shuttle have demonstrated the high utility and cost-effectiveness of space-based research and experimentation.

Technology experiments on missions scheduled for FY 1984 flights include the LDEF, the Solar Array Flight Experiment, the solar cell calibration facility, the tribology experiment, and a reflight of the Feature Identification and Location Experiment. Other experiments will be completing their integration and test programs in preparation for launch in FY 1985.

The IAPS will continue in the spacecraft integration and test activities directed towards a launch readiness in the latter portion of FY 1984.

The increased funding in FY 1984 for space flight experiments will permit completion of the design and the initiation of the development of several new in-space facilities and flight experiments.

These include: concept definition and design activities for an in-space structures and controls experiment and a cryogenic fluid management in-space facility. Additional flight experiment and concept definition activities will be initiated based on evolving requirements identified in the research and technology base program, technology urgency and funding availability.

STANDARDS AND PRACTICES

FISCAL YEAR 1984 FUNDING LEVEL

Standards and practices	$4,600,000

The objective of the standards and practices program is to support Agency goals through activities in systems engineering; reliability and quality assurance; safety; software assurance; and program practices which reduce program risks, improve product confidence, and encourage food program procedures in the technical execution of NASA programs.

During FY 1982, the Office of the Chief Engineer was reorganized to consolidate agency-level safety, reliability and quality assurance activities, and to assume four new areas of responsibility (aerospace flight systems; data and communication systems engineering; test and environmental systems; and engineering technology). This expansion of the oversight function in the engineering discipline area has the objectives of improving product quality, increasing confidence in NASA's ability to achieve mission objectives and accelerating the pace of achieving greater productivity. In FY 1982 and in FY 1983, reliability and quality assurance activities have emphasized solving concerns related to degradation of critical electronic parts in space applications; laying a solid foundation for testing and qualifying very large scale integrated (VLSI) circuits for future use in the space program; assessing and mitigating the effects of space radiation on electronics in space; developing nondestructive test techniques for verifying product quality; evaluating NASA-wide software practices with goals to improve productivity and reduce costs; and continuing materials and parts assurance activity. Program practices activities include continuing support to voluntary consensus efforts which will result in a new American Institute of Aeronautics and Astronautics (AIAA) standard for symbols and units for use in planning and design of large space structures; workmanship standards; support to the measurement of the Shuttle payload bay dynamic, acoustical and thermal environment; and providing electrostatic discharge information designed to achieve good practices which will minimize the potential loss of electronic systems containing microcircuit parts. In the area of safety, activities include assessing the ignitability of metals in oxygen; studies concerning safe siting in future pressure vessels; development of an accident investigation training program; and a project to assess the use of an in-flight aircraft data recorder to enhance maintenance procedures.

In support of the goals of the Agency, the FY 1984 standards and practices program will continue to conduct activities related to reliability and quality assurance, safety, software assurance, and program practices. The increase of funds from the FY 1983 level primarily reflects the increased responsibility of the restructured organization to address tasks directed toward systems engineering problems and toward technology areas affecting the efficiency and quality of NASA space and aeronautical products and testing. This increase in emphasis includes software engineering assurance, special technology reviews and risk assessments; improved assessment and evaluation of test facility capabilities, hardware and, particularly, software systems engineering assessments; and continuing special activities to maintain or improve productivity, quality and mission success. Non-destructive testing and evaluation techniques and standards will be extended to new materials, such as composites, and to developing pressure vessel hazard mitigation guidelines. The FY 1984 funds will also continue to provide for special Congressional or NASA directed taskings which result from technical problems arising from programmatic activities. Examples of recent special taskings are the examination of the FY 1983 aeronautical budget assumptions and a review of the Space Shuttle external tank production schedule, both tasks to be carried out by the continuing major NASA program change review capability provided by the National Academies of Sciences and Engineering. Other recent tasks include the aviation safety reviews at the Langley Research Center and the Johnson Space Center; evaluations of the Space Shuttle main engine test failures; an assessment of the solid rocket booster parachute failure on the fourth Shuttle flight; and an assessment of the extravehicular maneuvering unit (EMU) failures on the fifth Shuttle flight.

The rotorcraft guidance and navigation activity will emphasize remote site all-weather operations by conducting a series of simulations to explore high resolution radar application for zero-zero landings. Simulations will also focus on implementation of differential GPS concepts prior to flight investigation. Noise abatement flight path guidance will also be explored in simulation to assess the potential benefits of various concepts.

RSRA/rotor systems research will emphasize advanced configuration assessments of a modern four-bladed rotor and preliminary design of an advanced flight research rotor to be tested on the RSRA. Available airloads data from the AH-1G flight program will be analyzed and correlated with available theory and will be used as input to existing noise prediction programs for correlation with measured noise data. Final checkout will be achieved on the RSRA electronic flight control system in preparation for extended flight research activities. Analysis will be completed on data from the static calibration of the active isolation/balance system on the RSRA and simulation of RSRA flight test conditions will be carried out with the new RSRA interchangeable cab with integrated visual systems in order to verify the airworthiness of the research systems.

Advanced rotorcraft technology will focus on initial ground testing of the composite tilt rotor blades. Rotor noise tests will be conducted in small-scale and large-scale to continue research aimed at developing reliable prediction methodology for rotor systems. Structural dynamics research will emphasize the application of optimization techniques to large finite element analyses for the prediction of helicopter airframe vibration levels. Ground tests will begin to establish a data base for convertible engine concepts utilizing the TF-34 engine and research control system.

In order to advance the state of technology on vehicle concepts, an increased effort in advanced tilt rotor technology will be undertaken in the technology for next generation rotorcraft program with emphasis on exploring the means of improving the speed, range, and flying qualities of the tilt rotor class of vehicle. Advanced structural, aerodynamic, propulsion, and control concepts will be investigated. In addition, in a joint program with the Defense Advanced Research Projects Agency an RSRA vehicle will be modified to accept and flight test an X-Wing rotor system. The primary area of interest here is in the utilization of the RSRA unique capabilities to explore the start-stop phase of flight for the X-Wing concept in the speed range of 200 to 300 knots.

10. TRACKING AND DATA ACQUISITION PROGRAM, $700,200,000

FISCAL YEAR 1984 FUNDING LEVEL

Space network	$294,700,000
Ground network	231,500,000
Communications and data systems	159,800,000
Advanced systems	14,200,000
Total	700,200,000

The purpose of this program is to provide vital tracking, telemetry, command, and data acquistion support to meet the requirements of all NASA flight projects. In addition to NASA flight projects, support is provided on a reimbursable basis for projects of the Department of Defense and other Government agencies, commercial firms, and other countries and international organizations engaged in space research endeavors.

Support is provided for sounding rockets, balloons, research aircraft, Earth orbital and planetary missions, and deep space probes. The program includes support of the Space Shuttle flight program. The various types of support provided include: tracking to determine the position and trajectory of vehicles in space; acquisition of scientific and space applications data from on-board experiments and sensors; acquisition of engineering data on the performance of spacecraft and launch vehicle systems; reception of television transmission from space vehicles; transmission of commands from ground stations to spacecraft; communication with astronauts; transfer of information between the various ground facilities and central control centers; and processing of data acquired from the launch vehicles and spacecraft. Such support is essential for achieving the scientific objectives of all flight missions, for executing the critical decisions which must be made to assure the success of these flight missions, and, in the case of Shuttle missions, to insure safety of the crew. Tracking and acquisition of data for the spaceflight projects is presently accomplished through the use of a worldwide network of NASA ground stations. When the Tracking and Data Relay Satellite System (TDRSS) becomes operational, support will be provided by a system of tracking and data relay satellites in geosynchronous orbit working with a single highly specialized ground station. Ground facilities are interconnected by ground communications lines, undersea cables, and communications satellite circuits which are leased from communications carriers, both domestic and foreign. These interconnections provide the communications capability needed between spacecraft and the control centers from which the flights are directed.

To meet the support requirements levied by the wide variety and large number of flight projects, NASA has established three basic support capabilities to satisfy the needs of all classes of NASA flight missions. These are the Spaceflight Tracking and Data Network (STDN), which supports Earth orbital missions; the Deep Space Network (DSN) which supports planetary and interplanetary flight missions; and the Tracking and Data Relay Satellite System (TDRSS), which will provide all low Earth orbital mission support when it becomes fully operational. The STDN will remain the primary Earth orbital support network until three TDRSS spacecraft are launched, properly positioned, and have completed pre-operational testing to insure reliable mission operations support.

When the TDRSS is fully operational, a phaseout of selected STDN ground stations will be initiated. Certain facilities of the STDN will be retained to provide support to geosynchronous and highly elliptical missions which cannot be supported via the TDRSS, or to provide launch and Shuttle landing support. These remaining facilities, except for the launch and Shuttle landing support facilities, are to be consolidated with the DSN stations under the management of the Jet Propulsion Laboratory (JPL). The consolidation, when completed, will provide a single network to support geosynchronous, highly elliptical, and planetary missions. The consolidated network will also support those older spacecraft in low Earth orbit which continue to provide useful data.

Computation facilities are maintained to provide real-time information for mission control and to process into meaningful form the large amounts of scientific, applications, and engineering data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket launchings and flight testing of aeronautical research aircraft.

The Research and Development appropriation provides funds for: the cost of TDRSS service; operations and maintenance of the tracking and data acquisition facilities; the engineering and procurement of equipment to sustain and modify the various systems to support continuing, new, and changing flight project requirements; and the investigation and development of advanced tracking and data acquisition systems and techniques.

SPACE NETWORK

FISCAL YEAR 1984 FUNDING LEVEL

Tracking and data relay satellite system	$242,900,000
Space network operations	31,800,000
Systems engineering and support	20.000,000
Total	294,700,000

The Space Network consists of the Tracking and Data Relay Satellite System (TDRSS) and a number of NASA ground elements to provide the necessary tracking, telemetry, command, and communication services to low Earth-orbital spacecraft. The TDRSS itself consists of a three-satellite spacecraft system in geosynchronous orbit and a single ground terminal located at White Sands, New Mexico. The satellites communicate with the user spacecraft in space and relay information to and from the ground terminal. From the ground terminal, satellite and ground communication links interconnect the NASA elements of the network any any remotely located user facilities.

The FY 1984 request includes funding for: repayment of the loans extended by the Federal Financing Bank (FFB) for TDRSS development; operations payments to the TDRSS contractor; manpower and services necessary to operate and maintain the NASA elements of the network; systems engineering, logistics, and documentation support services to the network elements; and testing for compatibility and interface verification with user spacecraft such as Space Telescope.

Tracking and Data Relay Satellite System

The Tracking and Data Relay Satellite (TDRSS) objective is to provide space-to-space communication services between the TDRS and user spacecraft through a single ground terminal. From their position in geosynchronous orbit, the Tracking and Data Relay Satellites function as relays for all signals to and from the mission spacecraft. This unique system provides approximately a six-fold increase in orbital coverage over that provided by the complex of ground stations currently in use and is capable of accommodating data rates up to 300 megabits per second from a single user. These capabilities will privide tracking, command, telemetry, and communication services to the flight missions of the 1980's—the Space Shuttle era.

Intensive testing and integration activities are underway at the Kennedy Space Center (KSC) for the launch of the first TDRS, scheduled for early 1983, on STS-6. The second and third launches are scheduled for mid 1983 and the first half of 1984, to complete the initial operational constellation of TDRS. Environmental testing has been initiated on the second spacecraft and assembly of the third spacecraft is in process. The ground terminal is undergoing test and network integration to ensure readiness for the initial launch and early operations.

After a thorough review of NASA support requirements and their relationship to the operation of a shared service system, NASA recommended the restructure of the TDRSS contract to provide for a dedicated government system. This change to the service contract converts the TDRSS from a shared system providing support to both government space missions and commercial communication satellite services, to a system dedicated to providing support to space missions. Although the Space Communication Company (SCC) will remain as the owner-operator, it has relinquished its rights to the use of the commercial segment of the system. NASA will have the dedicated use of all six spacecraft provided through the service contract. The operational constellation of satellites will consist of three rather than four spacecraft, as the one formerly dedicated to commercial use will no longer be required. NASA gains improved management flexibility and control over the operation of the system and has the ability to make modifications to both spacecraft and ground systems to meet the needs of user missions. This contract change also provides the potential for extended system life since there will be three, rather than two, replacement spacecraft available on the ground to restore full NASA service in the event of spacecraft failure or degradation.

The decrease of $10.0 million reflects application of the general Congressional reduction in the budget request. Due to a revision in the date for initiation of loan repayments and a revised estimate in the total amount to be borrowed, loan payment requirements for FY 1983 were reduced.

Under the terms of the TDRSS service contract, loans were extended by the Federal Financing Bank (FFB) to the Space Communication Company (SCC), the owner-operator of the TDRSS. Under the terms of the loan agreement and assignment, NASA will repay these loans directly to the FFB. In addition, NASA will make operations payments to SCC for services once NASA accepts TDRSS service. Acceptance occurs when two on-orbit spacecraft have been tested and are operating on station.

Space Network Operations

The objective of Space Network Operations is to provide for the operation and maintenance of the associated NASA ground systems which, when combined with TDRS, provide a full array of reliable tracking, telemetry, command, and communication services to user spacecraft in low Earth orbit. Each of these systems provides specific functions for the Space Network.

The NASA Ground Terminal (NGT) monitors TDRSS performance and provides fault isolation monitoring for the network. The Network Control Center (NCC) schedules TDRSS services for all user spacecraft, and the Operations Support Computing Facility (OSCF) provides orbit determination, trajectory analysis, and position location for flight missions supported either via the Space Network or by the current Spaceflight Tracking and Data Network (STDN). The Bilateration Ranging Transponder System (BRTS) provides precision position location and orbit determination for the TDRS. The Simulation Operations Center (SOC) and the Compatibility Test Vans (CTV) provide necessary pre-launch testing, simulations, and interface verification for both user spacecraft and the various network elements to assure the operational readiness of the network to support a given mission. These systems are undergoing test and integration to confirm readiness to support the launch of the first TDRS. TDRSS mission and user simulations are being conducted; tests of the individual systems are being accomplished and will culminate in a series of end-to-end tests of the entire network. The complex software of the NCC for the Initial Operational Capability (IOC) is undergoing test and verification. The White Sands BRTS is in the process of test and checkout with the ground terminal. Other BRT systems are ready for final calibration and delivery to remote site locations for installation.

The funding request provides for contractor personnel to operate the network systems 24 hours per day, seven days per week, and to provide requisite hardware and software maintenance. A contract has been competitively awarded to provide these operation and maintenance functions. In addition, a variety of support services is provided in the areas of logistics, mission planning and documentation.

Systems Engineering and Support

The objective of Systems Engineering and Support is to provide for the implementation and the required engineering services to design, implement, and sustain the NASA systems of the Space Network. Engineering services are supplied primarily through the operations contract and a number of small, highly specialized engineering service contracts. Current emphasis is on the completion, test, and integration activities in preparation for the initial operations of the Space Network. Activities include test scenario design and development, system and subsystem level troubleshooting during simulations, end-to-end network testing, and operations procedure development.

Requested funding will provide for engineering support under the operations mission contract in the areas of systems engineering, performance and operations analyses, minor facility modifications, and network integration testing and interface verification. In addition, other contractors will supply sustaining engineering support, test equipment, and vendor maintenance for specialized equipment and subsystems within the Space Network. Design and analytical studies will be conducted on a wide array of items ranging from subsystem modifications to meet new mission requirements or to correct system deficiencies to the analysis of the radio frequency environment for potential impact on TDRSS and other network systems.

Funds are also requested for software and hardware development for the NCC Full Operational Capability (FOC), to complete procurement of replacement front-end processors for the NCC, and to complete the remaining implementation activities at the NASA Ground Terminal (NGT). The implementation of the FOC is required for upcoming missions such as the Space Telescope.

GROUND NETWORK

FISCAL YEAR 1984 FUNDING LEVEL

Spaceflight tracking and data network systems implementation	$8,100,000
Spaceflight tracking and data network operations	102,500,000
Deep space network systems implementation	38,100,000
Deep space network operations	66,500,000
Aeronautics and sounding rocket support systems implementation	8,100,000
Aeronautics and sounding rocket support operations	8,200,000
Total	231,500,000

The Ground Network includes the Spaceflight Tracking and Data Network (STDN), consisting of 16 geographically dispersed ground stations (11 permanent and five special purpose stations), which support Earth orbital missions; the Deep Space Network (DSN), consisting of three stations approximately 120 degrees apart in longitude for continous mission viewing, which supports planetary and interplanetary flight missions; and support for Aeronautics and Sounding Rocket (A&SR) programs at the Wallops Flight Facility (WFF), the Dryden Flight Research Facility (DFRF), and White

Sands Missile Range, as well as instrumentation support at the National Balloon Facility at Palestine, Texas.

Funding for the ground network provides for operation and maintenance of the worldwide facilities, as well as engineering and procurement of equipment to sustain and modify network systems. The workload in FY 1984 includes ongoing support to Shuttle, Voyager, Dynamic Explorers, International Ultraviolet Explorer, and the International Sun-Earth Explorer, as well as preparation for support of such upcoming missions as Galileo, the Voyager-Uranus encounter, and the Active Magnetospheric Particle Tracer Explorer (AMPTE). Support will be provided to aircraft programs such as the F-16 and F-111, the forward swept wing, and the use of drones for aerodynamic and structural testing.

The FY 1984 budget request reflects the planned phaseout of most of the STDN ground stations after TDRSS is operational. The remaining facilities will then be consolidated with the DSN stations under management of the Jet Propulsion Laboratory (JPL), or dedicated to support of launch and Shuttle landing operations. The consolidation will result in a single network to support geosynchronous, highly elliptical, and planetary missions.

Spaceflight Tracking and Data Network Systems Implementation

The Spaceflight Tracking and Data Network (STDN) systems implementation program encompasses the procurement and implementation of services to sustain network facilities and equipment to insure reliable tracking, command, and data acquisition support to ongoing scientific and applications satellite missions and the Space Shuttle, to selectively replace obsolete equipment for reliable launch support in the TDRSS era. Employing systems implemented in past years, the network is currently supporting many missions with highly complex requirements for tracking, data acquisition, command and control.

The FY 1984 request includes funds for the replacement of obsolete and difficult-to-maintain equipment used for launch support at Bermuda and Merritt Island, Florida. The requirement for launch support from these sites will continue for the foreseeable future.

Equipment modifications are required in the network in FY 1984 to maintain the required level of proficiency to support a diverse and demanding workload and to assure the reliability of the major systems. Accordingly, funds are required to replace portions of aging systems at the stations being retained, for equipment modifications to correct operational deficiencies, and for equipment to be used in operational control of the network. The funds requested also provide for procurement of major subsystem spares, for the provision and modification of test equipment, and for minor equipment modifications resulting from changes in mission-to-mission support requirements.

Spaceflight Tracking and Data Network Systems Operations

The primary function of the Spaceflight Tracking and Data Network (STDN) system operations is to support all NASA Earth orbital spaceflight missions, including the Space Shuttle. The majority of these missions have near-Earth orbits; however, the network also supports selected missions through lunar distances and beyond, such as the International Sun-Earth Explorer (ISEE) missions. In addition, the network provides launch support to NASA automated planetary missions, and on a reimbursable basis, spaceflight missions of other nations, commercial firms, and other United States government agencies. Accordingly, the network must be responsive to the requirements of a large number and wide variety of flight projects from launch through completion of the flight project objectives. In many instances, the period of network support required by flight projects continues for several years.

The STDN presently consists of 16 geographically dispersed ground stations. These global facilities have the capability to electronically track the spacecraft, send commands for spacecraft and experiment control purposes, receive and display engineering and scientific data from the spacecraft, and in the case of manned flights, maintain voice communications for crew operations and safety, and other project related purposes.

There are 11 permanent STDN land stations located at: Fairbanks, Alaska; Goldstone, California; Greenbelt, Maryland; Merritt Island, Florida; Kauai, Hawaii; Guam; Ascension Island; Canberra, Australia; Bermuda; Santiago, Chile; and Madrid, Spain. In addition to the 11 permanent stations, five additional facilities supplement the STDN, primarily for Space Shuttle support. A transportable station is located near NASA's Dryden Flight Research Facility (DFRF), California, for support of the Shuttle landings, and small transportable station is located at New Smyrna Beach, Florida, for support of Shuttle launch and landings. Also, three UHF/voice air-to-ground stations are located at Dakar, Senegal; Gaborone, Botswana, and Yarragadee, Australia, to provide additional voice coverage with the astronauts. Dakar has been augmented for S-Band operations. An Air Force station in the Indian Ocean is used to provide Shuttle support. An engineering test and network system training facility at GSFC is also maintained and operated as part of the STDN.

The FY 1984 funding requirements provide for the maintenance and operation of the STDN until phasedown begins in the April/May time period. Included in the funding request are the related logistics support, network planning, scheduling, engineering, documentation and software programming costs associated with the operations of the network.

The initiation of TDRSS service permits closure of several STDN stations in FY 1984—Ascension, Guam, Hawaii, Santiago, Dakar, and Botswana and the termination of activities at the Air Force Indian Ocean station and Yarragadee, Australia. Cessation of operations will result in a reduction to FY 1984 funding requirements.

Deep Space Network Systems Implementation

The role of the Deep Space Network (DSN) is to provide the communication link between each of NASA's distant planetary and interplanetary spacecraft and the Earth. The DSN is responsible for receiving science and engineering data, and providing the navigation, command and control capabilities from the ground to a constellation of spacecraft ranging in distance to over 3.7 billion kilometers from Earth. After the Tracking and Data Relay Satellite System (TDRSS) becomes operational, the DSN will also support spacecraft much closer to Earth. This new set of spacecraft will include highly elliptical Earth orbiters and synchronous Earth orbital missions which will be in orbits higher than those supportable by the TDRSS.

The systems and facilities required to support spacecraft at the limits of the solar system are highly specialized and include the use of large aperture antennas electronically configured in a phased array for optimum reception of the extremely weak radio signals. The antennas use ultrasensitive cryogenically cooled receivers and powerful transmitters. Extremely stable hydrogen maser time standards are required for precise navigation of distant spacecraft. Advanced data handling systems are required at both the DSN complexes and the Network Operations Control Center (NOCC).

The four major objectives for the DSN in the 1980's are as follows: (1) to provide communications channels to scientific spacecraft at ever-increasing distances and to provide the capability to receive images at these great distances; (2) to consolidate the activities of the residual Spaceflight Tracking and Data Network (STDN) with the DSN after the TDRSS becomes fully operational in 1984; (3) to provide support for a new set of spacecraft which will incude highly elliptical Earth orbiters and synchronous Earth orbital missions (both types will be in orbits at altitudes that are beyond the support area of TDRSS); and (4) to provide the improved navigation capabilities required for precise spacecraft targeting and probe delivery.

These objectives represent a significant challenge to the DSN, as it will be supporting many more spacecraft than in the past, and it will be working at extremely great distances (beyond the orbits of the known planets) by the end of the decade.

The next major planetary encounter will be of Uranus by Voyager 2 in 1986. This encounter will occur some 2.9 billion kilometers from Earth. At that time, Voyager 2 is expected to transmit the first images ever received from a spacecraft at such a distance. The newly consolidated network will receive its first major test of compound multiple antenna arraying (more than two antennas) during this Uranus encounter. In Australia, this will include the use of the 64-meter antenna of the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO). In addition, the design and implementation of the new consolidated network must provide the flexibility necessary to support older near-Earth missions that are not compatible with the TDRSS. To support these older spacecraft in their extended mission phase, and to provide backup support to the TDRSS itself, existing 26-meter GSTDN antennas will be moved and colocated with the DSN facilities at Canberra and Madrid.

New deep space missions which will be supported by the network in the 1980's include the Jupiter orbiter and probe (Galileo) and the International Solar Polar Mission (ISPM). One or more of Halley's Comet rendezvous missions will also be supported for the international community on a reimbursable basis.

Funding in the FY 1984 request provides for continuing the reconfiguration of the ground network facilities into a consolidated, modern, and highly reliable, automated network. The capabilities planned in the reconfiguration will provide for enhanced spacecraft-ground telecommunications and navigation precision while reducing overall maintenance and operations costs. Equipment required for this capability includes antenna monitors and controls, receiving and data handling systems, along with the necessary engineering and fabrication. Some equipment will be provided to augment the Parkes Antenna in Australia to properly handle and combine the signals received during the Voyager-Uranus encounter at that location.

In addition, funds are included for implementing a central signal processing center at each DSN complex. Instead of independent support facilities for each antenna, it will be possible to support all antennas at each complex from a central operations center. This center will include the digital electronics required for uplink command encoding, downlink demodulation, signal recording, and data transmission for all the antennas in the complex. Centralized, shared maintenance and support facilities will also be provided.

The overall design will allow antennas to operate either independently (with different individual spacecraft) or in an arrayed fashion (more than one antenna targeted on a single spacecraft) to achieve the increased aperture necessary to support the high data rates of missions such as Voyager 2 at Uranus. As the distance to the spacecraft doubles, the antenna aperture needed to provide an equivalent signal goes up by a factor of four, resulting in the need for extremely sensitive receiving equipment as well as increased antenna aperture through antenna arraying.

In conjunction with the evolution of the consolidated network, modifications are planned at the Network Control Center to facilitate scheduling, spacecraft acquisition and tracking, monitor and control, and overall coordination of the activities of the network. Funding also provides for continued development and improvement in flight navigation accuracy.

Concurrent with these important engineering changes, FY 1984 funds will be required to maintain the high level of reliability for support of time-critical spacecraft maneuvers as well as routine ongoing support. This will be accomplished through a continuing program of equipment and facility refurbishment and modifications to assure compatibility of existing equipment with the new system being implemented in the network.

Deep Space Network Operations

The three Deep Space Network (DSN) complex locations at Goldstone, California; Canberra, Australia; and Madrid, Spain, are approximately 120 degrees apart in longitude and permit continuous viewing of planetary spacecraft. Each complex currently consists of one 64-meter and one 34-meter diameter antenna; an additional 34-meter antenna is being constructed at Goldstone and Canberra.

A centralized control center for the network is located at the Jet Propulsion Laboratory (JPL) in Pasadena, California. JPL has field management responsibility for the network. Separate contracts exist for the operation of the Australian, Spanish, and Goldstone sites. The contract for the Goldstone station also includes network support activities and operations of the Network Control Center at JPL.

The current workload in the DSN consists of the two Voyager spacecraft, seven ongoing Pioneer spacecraft (Pioneer 6—11 and Pioneer Venus), the Viking 1 Mars Lander, and one Helios mission. Support of these missions will continue during FY 1984.

The Voyager 2 spacecraft is on a trajectory for an encounter with Uranus in early 1986, and should provide the first detailed information on that distant planet. Voyager 1 is now about 2.4 billion kilometers from Earth on a trajectory that will take it out of the solar system. Of the older Pioneer spacecraft, Pioneer 10 is over 4.1 billion kilometers from Earth, and along with Pioneer 11 is proceeding on a path that will take them beyond the solar system. Pioneer 10 continues to be the most distant man-made object communicated with; each time data is received by the DSN, a new communications record is established. It now takes nearly seven hours for a radio signal traveling at the speed of light to make the round trip between Earth and Pioneer 10. The Pioneer 11 spacecraft, some 2.0 billion kilometers from earth, continues to be tracked. The Pioneer 6-9 spacecraft are provided support during solar conjunctions and during gravity wave experiments. The Helios 1 mission is continuing its orbit about the Sun.

The DSN facilities are also used on a noninterference basis for ground-based measurements in support of experiments in planetary radar mapping and in the field of radio astronomy. The ultrasensitive network antennas are being used in an attempt to learn more about the mysterious pulsar high energy sources, quasars, and other interstellar phenomena.

In addition to the activities associated with network modifications and the support cited above, the DSN operations workload includes preparation for several future missions including the ISEE-3 spacecraft as it makes the first comet intercept (Giacobinni-Zinner Comet), the Galileo spacecraft (the mission to Jupiter), Giotto (the reimbursable European Space Agency (ESA) mission to Halley's Comet), and the multi-national Active Magnetospheric Particle Tracer Explorer (AMPTE) mission. This support preparation requires thorough and complex testing, training, and engineering involving both hardward and software. These activities must be carried out simultaneously with the extensive ongoing DSN workload, and must be done in such a way as to cause minimum disruption to ongoing flight project support.

In preparation for the Voyager 2 encounter with Uranus, an additional 34-meter antenna is being constructed at both Goldstone and Canberra. These antennas will be electronically combined with the other facilities at their respective complexes so as to further increase the receiver gain available at these two stations which are both key to capturing imaging data from Uranus. The DSN complex at Canberra, because of its southern hemisphere location, will have the best view of Voyager 2 at Uranus. At that location, an additional facility will be used at the time of encounter; that facility is the Australian 64-meter Radio Observatory at Parkes, which will be electronically combined with an array of DSN antennas. ESA is planning to use this same radio observatory facility in support of their Giotto mission to Halley's Comet. The arrival of Giotto at Halley's Comet at a time close to the Voyager 2 Uranus encounter will require close coordination between NASA, the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia, and ESA in order to assure success.

The DSN operations funding provides for the maintenance and operation of the network facilities, control center, and the support and enginerring effort associated with continuing operation of the network. The funds requested for FY 1984 are based upon the ongoing workload, including the Voyager mission, Pioneer 6–11 missions, Pioneer-Venus extended mission, Helios mission, and Viking Lander mission, and the preparation required for the upcoming activities mentioned above.

Aeronautics and Sounding Rocket Support Systems Implementation

The objective of the Aeronautics and Sounding Rocket Suppport (A&SR) Systems Implementation program is to provide fixed and mobile instrumentation systems to meet the tracking, data acquisition, and range safety requirements of the aeronautical research conducted at the Wallops Flight Facility (WFF) in Virginia, the Dryden Flight Research Facility (DFRF) In California, and the scientific investigations conducted with balloons and sounding rockets at Wallops and other selected sites around the world.

The aeronautical research efforts and scientific experiments using sounding rockets and balloons are programs of a continuing nature which generally require about the same level of support from year to year. To support these programs, WFF provides fixed and mobile instrumentation systems; namely, radar, telemetry, communications, command, data handling and processing systems. To maintain these facilities, replacement parts must be acquired, and test and calibration equipment routinely replaced.

Due to the age of some of the radar, telemetry, and impact prediction equipment, a phased replacement and refurbishment program is underway to insure reliable real-time data collection and handling support to meet current and future requirements.

Funds are also included in the budget request for implementation of a second telemetry acquisition system at the DFRF to permit support of two missions simultaneously in order to accommodate the increase in flight research activity of that facility, and a Telemetry Post-mission Processing System which will permit support of post-mission formatting and flight replays without interfering with real-time mission support.

Aeronautics and Sounding Rocket Support Operations

Fixed and mobile instrumentation systems are maintained and operated to support sounding rocket, balloon, spacecraft and aeronautical programs conducted by the Wallops Flight Facility (WFF) and the aeronautical flight research programs of the Dryden Flight Research Facility (DFRF). These instrumentation systems include radar, telemetry, data processing, data handling, and communications systems, as well as special purpose optical equipment.

The Sounding Rocket program continues to be an active program with approximately 200 launches in FY 1982, the majority of which were conducted at WFF. In addition, there were over 50 large scientific balloon flights during the same period. At WFF, the aeronautical programs are primarily related to investigation of aircraft handling characteristics, advanced control and display concepts, spin and stall tests, terminal area guidance and traffic control systems, and noise studies. Approximately 200 missions were conducted during 1982. In addition to support of sounding rocket, balloon, and aeronautical programs, instrumentation at WFF will continue to be utilized to support the Shuttle orbital flights.

Dryden Flight Research Facility operates the aeronautical test range which provides radar, telemetry and communications support for the performance of aircraft research and development programs. A variety of programs is conducted involving high performance aircraft, such as the F-111, F-14, F-16, F-104, F-8, and research vehicles such as the tilt-rotor research aircraft, and drones for aerodynamic and structural testing. Over 400 aeronautical research missions were supported at DFRF during FY 1982. DFRF was the prime landing site for STS-2, -3, and -4, and tracking and data acquisition support of Shuttle orbital flights will continue in the future.

The FY 1984 funding requirements provide engineering and technical services for maintenance and operation of fixed and mobile radar, telemetry, communications, and data handling and processing equipment and facilities to support the ongoing sounding rocket, balloon, and aeronautical research activities. The effort funded represents a continuation of the baseline support provided to the aeronautics, sounding rocket, and balloon programs.

COMMUNICATIONS AND DATA SYSTEMS

FISCAL YEAR 1984 FUNDING LEVEL

Communications systems implementation	$5,300,000
Communications operations	59,700,000
Mission facilities	11,500,000
Mission operations	18,600,000
Data processing systems, implementation	22,400,000
Data processing operations	42,300,000
Total	159,800,000

Funds requested for the Communications and Data Systems program provide for the implementation and operation of facilities and systems which are required for data transmission, mission control and data processing support.

Communication circuits and services are necessary to transmit data between the remote tracking and data acquisition facilities, launch areas, and the Mission Control Centers. Real-time information and post-generation of commands for spacecraft and payload control. Data received from the various spacecraft must be processed into a usable form before transfer to control centers and experimenters. Such support is mandatory for achieving mission objectives. Missions supported include Shuttle, NASA scientific and applications missions and international cooperative efforts.

Communications Systems Implication

The objective of the Communications Systems Implementation Program is to provide the necessary capability in NASA's Global Communications Network (NASCOM) to meet new program support requirements, to increase the efficiency of the network, and to keep NASCOM at a high level of reliability for the transmission of data. NASCOM interconnects the tracking and data acquisition facilities which support all flight projects; it also links such facilities as launch areas, test sites, and mission control centers.

The major efforts underway in NASCOM are the procurement, implementation, and programming of a Control and Status System that can remotely control the configuration of the Tracking and Data Relay Satellite System (TDRSS) multiplexing system located at White Sands, New Mexico. Funding is also provided to replace equipment in the voice and data message switching system at the Goddard Space Flight Center (GSFC).

The FY 1984 funding requirements will provide the sustaining equipment and modifications to support the NASCOM network and to complete the implementation and programming efforts on the Control and Status System which will remotely control the configuration of the baseline and high data rate multiplexing equipment located at the White Sands Ground Terminal, Johnson Space Center, and the Goddard Space Flight Center. Efforts will continue on the use of advanced digital techniques for Time-Division-Multiple-Access (TDMA) via satellite and on the use of fiber optic cables for high data rate distribution in support of Spacelab and Space Telescope.

Communications Operations

NASA's Global Communications Network (NASCOM) interconnects, by means of leased voice, data, and wideband circuits, the tracking and data acquisition facilities which support all flight projects. NASCOM also links such facilities as launch areas, test sites, and mission control centers. Goddard Space Flight Center (GSFC) operates the NASCOM and serves as its major switching control point. In the interest of economy, reliability, and full utilization of trunk circuitry, subswitching centers have been established at key domestic and overseas locations.

The NASA flight projects require the transfer of data between the mission control centers and the tracking sites because of the need for real-time control of spacecraft and on-board experiments. In addition, there are requirements to provide experiment data expeditiously to users for analysis.

In order to meet high data transfer rate requirements, NASA has implemented and will continue to use digital and other newly developed techniques in providing communications support. The continuing availability of new technology provides for the transmission of increasing amounts of data in a cost effective and highly reliable manner.

The FY 1984 funding requirements for Communications Operations will provide the circuits and service required to operate and maintain the NASA Global Communications Network. International communications satellites and cables will continue to be used to provide digital wideband services to all the overseas tracking stations. The domestic satellite systems and terrestrial networks will continue to service the continental United States stations. These services will provide for real-time transfer of data for all ongoing flight programs.

Funding increases in FY 1984 are due to the requirement for a 50 megabit per second (MBS) digital wideband service from the

Tracking and Data Relay Satellite System facililty at White Sands to both the Goddard Space Flight Center and Johnson Space Center to support the high data rates of Spacelab and Landsat-4 Thematic Mapper, and for the upgrade of the White Sands baseline capability to 4 MBS to handle the lower data rates associated with Shuttle and its payloads.

A second increase in FY 1984 is due to a transfer in budget responsibility for the Program Support Communications Network which handles day-to-day voice, data, facsimile, and teleconference circuits among Headquarters, NASA Centers, and contractors. Funding is now centralized in the Office of Space Tracking and Data Systems for more efficient program management.

Mission Facilities

The Mission Facilities Implementation program provides the systems capability for the command and control of NASA's unmanned scientific and applications satellite programs. Command and control capability is realized through the provision of Payload Operations Control Centers (POCC's) and related Mission Support Systems (MSS).

The POCC's are responsible for the receipt, processing, and display of spacecraft engineering data and the transmission of commands. Five POCC's monitor and currently control numerous spacecraft. In addition, a new dedicated control center is being implemented to control the operations of the Space Telescope to be launched in FY 1985. Related Mission Support Systems include a Johnson Space Center/Goddard Space Flight Center Shuttle POCC interface facility and a closed circuit television and data communications system.

The FY 1984 funding requirements will provide for the continuing development of the Space Telescope Operations Control Center. Two major activities, the Preliminary Operations Requirements and Test System (PORTS) and Payload Applications Software System (PASS), plus a test and validation effort will be underway to meet the FY 1985 launch date. The control center hardware installation will be completed and integration testing with the spacecraft on the ground will begin. The offline software which provides the high precision telescope pointing, manipulation of the cameras and spectographs, pointing of the spacecraft antenna toward the TDRSS, and energy and momentum management of the vehicle itself, will require additional development and testing. Funds are necessary to assure that the PORTS, PASS, and Data Capture Facility operate as an integrated system.

In addition, FY 1984 funds will provide for modifications to the existing Multisatellite Operations Control Center (MSOCC) for control of the upcoming Gamma Ray Observatory (GRO) and Cosmic Background Explorer (COBE) spacecraft, and for sustaining activities such as changes to interface devices and replacement of obsolete equipment.

Mission Operations

The Mission Operations program provides for the operation of five Payload Operations Control Centers (POCC's), a Mission Operations Center, and the related software and support services necessary for the monitoring and control of 18 in-orbit spacecraft.

The POCC's, which are the control facilities for spacecraft/payload operations, contain all of the necessary equipment, software, and personnel needed to monitor, evaluate, and control the performance of spacecraft and experiments. Each POCC is operated 24 hours per day, seven days per week by contractor personnel. For Shuttle launches with control center payloads, the POCC will issue commands and receive telemetry through the GSFC Shuttle Payload Interface Facility (SPIF). The SPIF will also process a variety of Shuttle-unique data and display these data to the POCC via closed circuit television.

The FY 1984 budget request includes funds to operate the POCC's and supporting facilities for the control of on-orbit missions. Also in FY 1984, POCC and Command Management software development activities will be initiated for both the COBE and GRO missions. Software to enable the POCC to work with the consolidated network will be developed and efforts will continue on SPIF software modifications.

Also included in the FY 1984 budget request are funds for software and related support services which include maintenance of a software library, coordination and display of launch data, computer generated command sequences, equipment maintenance, logistics, documentation, engineering services and operation of a closed circuit television/data communications system.

Data Processing Systems Implementation

The Data Processing Systems Implementation program provides for the procurement of equipment and related services for the large computer complexes at the Goddard Space Flight Center which support both the operational and payload requirements of space missions. To meet operational requirements, these computer complexes determine spacecraft attitude and orbit, and generate commands to the spacecraft that provide the status of on-board subsystems. In support of spacecraft payloads, the computer systems process the data from science and applications experiments for subsequent transfer, to the experimenters for analysis.

Significant activities in this program continue at the Goddard Space Flight Center to keep the large complexes viable and responsive to project support requirements. The Telemetry On-Line Processing System (TELOPS) is routinely supporting a number of Earth orbiting spacecraft. The Image Processing Facility (IPF) is generating products for Landsat and Nimbus 7. The program to replace many of the old computers continues. The new Metric Data Facility was placed on line in mid-1982 and the old system retired. Implementation continues on a new system to process data from numerous and varied experiments which comprise the payloads of early Spacelab missions.

The FY 1984 budget request will provide continued funding for phased replacement of the existing computer complex at the Goddard Space Flight Center (GSPC) which provides real-time support to NASA spacecraft. Included in the support are such critical activities as real-time attitude and orbit determination, memory management for on-board computers, and flight maneuver control. This computer complex is approximately 17 years old. The system architecture of the existing system requires more extensive software development to meet new mission requirements. Replacement is needed because hardware and software maintenance is becoming more difficult and expensive, and more frequent outages are becoming a threat to spacecraft support.

The FY 1984 funding request provides for continuation of the phased computer replacement program for the flight dynamics, command management system, and the orbit computation system at GSFC. The orbit computation replacement system will have a complex task of not only supporting free-flyer spacecraft, but also the Shuttle and the Tracking and Data Relay Satellite System (TDRSS). Maintaining the TDRSS position accuracy will impose a significant demand on the orbit computation system resources.

In addition, funds are required for the implementation of a stand-alone Space Telescope Data Capture Facility which will capture, error check, and ship scientific data to the Space Telescope Science Institute. The system is necessary to handle the planned "Packet" telemetry requirement and to assure support over the long mission lifetime of the Space Telescope. The "Packet" telemetry concept allows the scientific data of an experiment to be handled with minimum involvement by the ground system, thus minimizing ground data processing time as well ensuring faster delivery of data to the experimenters. FY 1984 funds are requested also for a general purpose, multimission system to handle packet telemetry with the Gamma Ray Observatory (GRO) as its first user.

There is a continuing requirement to procure and maintain an adequate supply of spare parts to replace failure-prone and high-maintenance electronic modules, to provide test equipment, and to undertake minor modifications and hardware fabrication associated with new equipment installation and reconfiguration.

Data Processing Operations

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a usable form before transfer to control centers and experimenters. This transformation and computation process is performed as part of the data processing function and applies to a wide variety of programs, ranging from the small explorer satellites to complex Landsat satellites.

Tracking data is processed to provide orbital information which is used to compute spacecraft position. This is essential for the real-time control of spacecraft, for determining when the spacecraft will be passing over the stations so data can be acquired, and for providing precise information that can be used by the scientific experimenters to determine where in the trajectory of the spacecraft the scientific measurements were made. Telemetry data must be processed to separate the information obtained from various scientific experiments aboard the spacecraft, consolidate information for each experimenter, determine spacecraft attitude, and correlate these measurements with the position data. Processed data is the primary product of the spacecraft missions, and it is through reduction and analysis of this data by the experimenters that the planned objectives are achieved.

In addition to the actual processing of the data, upcoming projects require extensive prelaunch orbit analysis including spacecraft position and attitude predictions. Analyses are also required to develop operational sequences and procedures to be used during the actual operation of the complex spacecraft. Examples of these activities are: the final checkout and acceptance of the operational orbit support software for the first Tracking and Data Relay Satellite (TDRS) to be launched early in 1983; and, the analysis and development of the operational software for the Bilateration Ranging Transponder System for the support of the TDRSS.

As part of the data processing activities, two facilities, the Image Processing Facility (IPF) and the Telemetry On-Line Processing System (TELOPS), have been established at the Goddard Space Flight Center to process different types of raw experimental data.

The IPF, initially established to handle image data from the Landsat-1, had continued to support the second and third Landsat spacecraft as well as Nimbus missions. These spacecraft are being supported with an all-digital system using high density and computer compatible tapes which have reduced the time required to provide data to users.

The Telemetry On-Line System (TELOPS) handles the non-image data. TELOPS receives satellite data in a dignital form from the tracking stations via the NASA global communications network lines and is able to electronically store large volumes of telemetry data, thus eliminating most of the tape and tape handling operations. Facility management, maintenance and operations, and software development support for the image and non-image data processing facilities are also provided. The operation of the Spacelab Data Processing Facility (SDPF) is included along with software development and maintenance required for attitude determination, flight maneuvers, and mission simulations. The SDPF will be completed during 1983 and prelaunch operations and training will begin.

The FY budget request includes funds to operate the Image Processing Facility and the Telemetry On-Line Processing System to process data from currently orbiting satellites and from missions scheduled to be launched through FY 1984. The requirements for the acquistions and processing of data from the older satellites are under continual review as support for older missions is terminated or curtailed, as mission objectives are achieved, or when the experiment data is no longer useful or cost effective to acquire and process. Funds will also be required for operation of the SDPF.

Software development activities are continuing or will be initiated in support of upcoming space science and applications missions such as Space Telescope, Earth Radiation Budget Satellite, and the Gamma Ray Observatory which will operate with the Tracking and Data Relay Satellite System. Complex software is required for spacecraft on-orbit and attitude control maneuvers and for the related data processing activities.

ADVANCED SYSTEMS

FISCAL YEAR 1984 FUNDING LEVEL

Advanced systems	$14,200,000

The overall objective of the Advanced Systems program is to perform studies and provide for the development of tracking and data systems and techniques required to: (1) obtain new and improved tracking and data capabilities that will meet the needs of approved new missions and near term new starts; and (2) improve the cost effectiveness and reliability needed for overall support of the total mix of spaceflight missions.

This program remains a vital element in the space tracking and data acquisition program. Activity continues under this program to assess the dramatic changes taking place in the state-of-the-art in telecommunications and computer technology. Such effort is critical for proper planning and for the application of new technology to future support capabilities that are cost effective and reliable. Efforts include the investigation of upcoming missions and studies of ground systems and telecommunications links to determine design approaches and overall trade-offs for the lowest life-cycle costs to support future space missions.

The Advanced Systems program is accomplished mainly through contracts managed by the Goddard Space Flight Center (GSFC) with emphasis on support of Earth-oriented satellite missions and by in-house personnel at the Jet Propulsion Laboratory (JPL) focusing on deep space missions.

The following are examples of activities planned for FY 1984. New and extremely precise radiometric tracking techniques will be investigated for determining angular direction of planetary missions to an accuracy of five nano-radians and establishing more accurate time standards sufficient for Earth-based navigation of future missions including flyby, orbiters, landers and probe releases. Such accuracy will also be valuable to ground-based science experiments, including precision relativity and the search for gravity waves.

In the area of telecommunications, where improvements benefit all future spacecraft, investigations will continue on the application of technology for more effective use of ground facilities. Studies include the use of the 64-meter diameter antennas at millimeter wave frequencies and the development of a cryogenically cooled telemetry receiver and antenna feed system capable of multiple frequency operation at K, X, and S-bands. Technical support will continue on the evaluation of an X-band uplink transmitting system. The application of such technology allows for reductions in spacecraft weight and power, greatly improves telemetry reception at the distances of the planets Uranus and Neptune, increases the amount of imaging data that can be returned from distant spacecraft, and provides for new ground-based science experiments. The use of optical frequencies and satellite relay links to meet planetary telecommunication needs beyond the 1980's will be investigated in terms of cost and performance trade-offs over micro-wave options.

During the TDRSS era, Earth orbital missions will acquire and handle data rates up to 300 million bits per second, an increase over the current requirements by a factor of 20. These future requirements result from high resolution sensors such as multispectral scanners and synthetic aperture radars. New techniques and systems will be developed for ground transfer and processing of high volume data. These include computer assisted operations, digital processing of high volume data, better man-machine interfaces, and wide band satellite communications to distribute data to processing centers and users. Optical disc data storage and automated quality control of data will be investigated to facilitate handling the increased image data processing requirements anticipated for future missions.

Methods and techniques will be investigated to reduce future manpower needed to operate the mission control facilities and to provide the necessary real-time interaction between the spacecraft experimenters and their experiments. Studies include the use of automated mission control techniques such as voice control and use of microprocessors for distributed command management.

CONSTRUCTION OF FACILITIES, $138,920,000

The Construction of Facilities (CoF) authorization provides for contractual services for repair, rehabilitation and modification of existing facilities; the construction of new facilities; the acquisition of related facility equipment; the design of facilities projects and advance planning related to future facilities needs.

The funds requested for 1984 provide for: The continuation of prior year's endeavors in meeting the facilities requirements for the Space Shuttle; Space Shuttle Payload support operations; modification of aeronautical research and development facilities; repair, rehabilitation, and modification of other facilities to maintain, upgrade and improve the usefulness of the NASA physical plant; minor construction of new facilities; and facility planning and design activities.

The projects and amounts in the budget estimate reflect Space Shuttle and Space Shuttle Payload requirements that are time sensitive to meet specific milestones. Other program requirements for 1984 include the construction of a data analysis facility at the Ames' Dryden Flight Research Facility; rehabilitation and modification of utility systems at the Goddard Space Flight Center and rehabilitation of the Airfield at Goddard's Wallops Flight Center; modifications to the transonic dynamics tunnel and modifications to the 4- by 7-meter low speed tunnel at the Langley Research Center; and, modifications of the 450 PSI air system and modification of rocket engine test facility for altitude testing at the Lewis Research Center.

The fiscal year 1984 program continues to meet the objectives of preserving and enhancing the capabilities and usefulness of existing facilities and to ensure safe economical and efficient use of the NASA physical plant. This request continues the necessary rehabilitation and modification program as in prior years and continues a repair program. The purpose of the repair program is to restore facilities to a condition substantially equivalent to their originally designed capability. The minor construction program continues to provide a means to accomplish smaller facility projects which accommodate changes in technical and institutional requirements. This program also includes projects which continue NASA efforts to reduce the consumption of energy.

Funds requested for facility planning and design cover advance planning and design requirements for potential future projects, master planning, facilities studies, engineering reports and studies and the preparation of facility project design drawings and bid specifications.

CONSTRUCTION OF FACILITIES

SUMMARY

Projects	Authorization FY 1984	Page No.
1. Space Shuttle facilities at various locations as follows:		
A. Modifications for additional chillers for Mission Control Center; Lyndon B. Johnson Space Center	$2,300,000	174
B. Modifications to Mobile Launch Platform No. 3; Kennedy Space Center	29,120,000	175
C. Modifications to the Manufacturing and Final Assembly Facilities for external tanks; Michoud Assembly Facility	11,700,000	177
2. Space Shuttle Payload Facilities:		
A. Construction of Cargo Hazardous Servicing Facility; Kennedy Space Center	9,000,000	179
B. Modifications to Spacecraft Assembly and Encapsulation Facility (SAEF-2) for cargo processing; Kennedy Space Center	3,000,000	179
3. Construction and modifications at the Jet Propulsion Laboratory:		
A. Construction of Frequency Standards Laboratory	2,700,000	180
B. Modifications to Space Flight Operations Facility	1,600,000	180
4. Construction of Fluid Mechanics Laboratory; Ames Research Center	3,900,000	181
5. Construction of Aeronautical Tracking Facility; Dryden Flight Research Facility	800,000	182

SUMMARY—Continued

Projects	Authorization FY 1984	Page No.
6. Modifications to Langley Research Center:		
A. Modifications and addition for Composite Materials Laboratory (1293A)	5,100,000	182
B. Modifications to 30-by-60-foot tunnel (643)	4,400,000	183
7. Modifications to Lewis Research Center:		
A. Modifications for Small Engine Component Testing Facility	7,000,000	184
B. Modifications to Icing Research Tunnel	3,600,000	185
8. Relocation of 26-meter STDN antenna, Spain	1,700,000	185
9. Repairs of facilities at various locations	19,500,000	185
10. Rehabilitation and modification of facilities at various locations	24,500,000	187
11. Minor construction of new facilities and additions to existing facilities at various locations	4,800,000	188
12. Facility planning and design	9,200,000	188
General reduction	5,000,000	
Total, construction at facilities	138,920,000	

1. SPACE SHUTTLE FACILITIES AT VARIOUS LOCATIONS, $41,300,000

A. MODIFICATIONS FOR ADDITIONAL CHILLERS FOR MISSION CONTROL CENTER: $2,300,000

This project provides additional water cooling capacity and electric power capacity to the Mission Operations Wing (MOW) of the Mission Control Center at Lyndon B. Johnson Space Center. The MOW provides all mission control functions for the Space Shuttle flights. Hence, the success of these flights depend upon the proper functioning of this control center.

Currently, the control center operates with two 700-ton chillers, one primary, or on-line chiller, and one back up chiller. When the cooling load exceeds 700 tons, however, both chillers must be operated simultaneously thus leaving no chiller in standby. Furthermore, with two 700-ton chillers operating simultaneously, the second chiller is required to cool only about 250 tons while it is consuming almost as much energy as the 700-ton chiller operating at full capacity.

Presently, during warm weather the cooling load exceeds the capacity of the one 700-ton chiller. Moreover, estimates show that by 1984 the increases in the flight rate and installation of additional technical equipment and computers in the control rooms will create a cooling demand which will regularly be in excess of 700 tons, regardless of the weather conditions.

To alleviate this situation, the proposed project will install two 400-ton chillers. One of the 400-ton chillers will be placed on-line with a 700-ton chiller, comprising a unit with an 11,000 ton capacity. This combination will adequately and efficiently meet the cooling demand increases of the future. In case of a failure of either the 700-ton or 400-ton primary chillers, either a 700-ton or a 400-ton chiller, depending upon the requirement, could be brought online. Also, this set will allow for any one of the four chillers to be taken out of service for periodic maintenance.

The simultaneous use of both a 700-ton and a 400-ton chiller, however, will increase the electric power demand. Likewise, the addition of technical equipment and computers will further increase the power demand. These demand increases could be met by using more commercial power. But then a commercial power outage could not be tolerated, because the back up power source could not meet the demand increases. So this project will also provide an additional diesel-driven generator as a back up electric power source.

If either item of this project, the two chillers or the power generator, was not approved, the shuttle simulations and missions would have been severely constrained, and the 24 flights per year schedule could not be supported.

B. MODIFICATIONS TO MOBILE LAUNCH PLATFORM NO. 3: $129,120,000

This project provides for the modification of an existing Apollo era mobile launch platform (MLP) to adapt it for use in the Space Shuttle program. Also included in this project are the utilities needed to test the modified MLP at its park site.

In the early 1970's when the Space Shuttle program was still in the developmental phase, an evaluation revealed that the mobile launchers used for the Apollo program could, with major modifications, be used to effectively launch space shuttle vehicles. Two of the Apollo era MLP's have been modified and are currently serving in the shuttle program.

Earlier estimates indicated that each of these modified MLP's would ultimately support 15 to 16 launches per year. Experience from the four developmental flights and the first operational flight have, however, shown that the ultimate launch rate for a single MLP appears to be 8 per year. Based on these projections, planned launch rates for the fourth quarter of 1986 and beyond will exceed the capabilities of the first two mobile launchers. So to meet the planned launch rate, a third MLP needs to be modified for shuttle operations.

The MLP which will be modified in this project was originally designed and constructed to accommodate Apollo hardware. It is a two-story steel structure, 25 feet high by 160 feet long by 136 feet wide. An umbilical tower rises 380 feet above the deck of the launch platform and weighs approximately 10.5 million pounds. A launch pedestal weighing approximately 1 million pounds, used for launching a Saturn 1B with a Skylab payload, rises 127 feet above the launch deck. The platform contains: electric power; gaseous nitrogen and helium; a deluge system; heating, ventilating, and air-conditioning (HVAC); and a fire extinguishing system. Much of the piping and cabling is contained inside the platform. Propellant lines for liquid hydrogen run outside the platform to the spacecraft.

The modifications required to adopt this third MLP to shuttle operations are virtually the same as those accomplished for the two previously modified MLP's. These modifications are catagorized into the following areas:

—Removal of tower and adapter;
—Structural modifications;
—Mechanical modifications;
—Electrical modifications;
—Water systems modifications.

The removal of the tower and adapter is required to reduce the weight of the MLP. The weight of the shuttle vehicle as it moves to the launch pad exceeds the weight of the unfueled Apollo/Saturn V vehicle by approximately 1.9 million pounds. This increase would overload the crawler transporter. But by removing the tower, two elevators, and other equipment inside the mobile launcher which are not required for shuttle operations 2.6 million pounds can be removed. Shuttle operations do not require this tower and associated equipment because the shuttle is serviced from a fixed tower at the launch. The umbilical towers on the previously modified mobile launchers were removed as part of the CoF modifications because they were required for use at Pad A and Pad B. The umbilical tower and launch pedestal on this third mobile launcher are not required for the Shuttle Program. Therefore, they are being excessed and are not included in this CoF project

Structural modifications are the most extensive of all modifications and absorb ⅗ of the project's estimated funds. First, the shuttle requires three exhaust openings, instead of one required by the Apollo vehicle. The platform thus has to be reconfigured with one 32 feet by 35 feet opening for the orbiter's main engines and two 20 feet by 42 feet openings for the solid rocket boosters. Second, the gas pressure exerted on the blast deck of the MLP by the solid rocket motor exhaust will in some cases exceed the pressure load which the deck is currently configured to withstand. So the platform's main members and its blast deck require structural upgrading. Third, the shuttle requires new support and holdown points for the solid rocket boosters and new support points for the orbiter erection support. Likewise, in order to balance the platform on the crawler transporter, the support points of the MLP will have to be relocated. Finally, the framing, deck plates, heat shield, and hold-down arm, which are not required for shuttle operations, will all be removed.

Modifications to the mechanical systems are required to accomodate them to shuttle operations. The reconfiguration of the exhaust openings necessitates that the following mechanical systems be rerouted: the pipes for the HVAC system; the ducts for the environmental control system; and lines for the pneumatic, propellant, water, and coolant systems.

Likewise, the following components of the electrical system require modification: the instrumentation; communication lines; controls; 60-Hertz power; lighting; and the lighting protection system. A new fire alarm system and hazardous gas detection system will also be provided.

Modifications to the water system are required to accomodate the MLP to the shuttle's acoustic attenuation operation. In order to reduce the excessive acoustic levels produced by the shuttle at launch, a high preasure water injection system was installed on the launch pad. This system has the capacity to deliver 400,000 to 500,000 gallons of water per minute to absorb some of the sound produced at launch. Although the water storage facility and the major elements of this system are located on the launch pad and not on the MLP, piping and nozzles must be provided on the platform itself. This water injection system is independent of the water quench system.

The following table provides a summary of the estimated cost for the individual areas of modification:

Mobile Launch Platform	$25,100,000
Removal of tower/adapter	(374,000)
Structural	(15,464,000)
Mechanical	(7,240,000)
Electrical	(1,300,000)
Water systems	(722,000)
MLPL park/maintenance site utilities	2,200,000
Preservation of Launch Umbilical Tower (LUT)	1,820,000
Total	29,120,000

C. MODIFICATIONS OF MANUFACTURING AND FINAL ASSEMBLY FACILITIES FOR EXTERNAL TANKS; MICHOUD ASSEMBLY FACILITY: $211,700,000

This project provides for continued modifications to the Michoud Assembly Facility (MAF), which produces the External Tanks for the Space Shuttles. The External Tanks (ETs) are responsible for supplying propellent to the Orbiter's main engines. Currently MAF is equipped to produce only 18 ETs per year. In order for the plant to scale up its production rate to 24 ETs per year, modification will have to be made at both the Main Manufacturing Building 103, and at Building 303.

Modifications at the Main Manufacturing Building 103 involve the construction of two additional feeder aisles, expanding the crane coverage, and increasing the capacity for spray on foam insulation (SOFI).

First, the addition of a 35 foot wide feeder aisle running North/South is needed to provide for efficient transport of large components from the receiving and inspection area to the production control areas. A second 24 foot wide feeder aisle running East/West is needed to ensure that nonproduction activities, such as maintenance personnel and equipment movement, do not interfere with production flow. These aisles are continuations of the program to increase the production flow in the plant; a goal which was initiated in prior years by the construction of a 45 foot aisle running East/West for the entire length of the plant.

Second, the overhead crane system will be expanded in order to serve three additional areas of the plant. This expansion will also contribute to the improvement of production flow through the plant. These improvements will cut the cost of receiving, transporting, and handling of components, and will make achievable the production goal of 24 ETs per year.

Third, the expansion of the SOFI area will allow for more and bigger components to be treated. This insulation protects the interface hardware from ice and debris during launch. 44 components which were previously treated with only an ablator material will now be coated with SOFI. The existing SOFI area will not accommodate the larger components scheduled to be treated, and the application equipment cannot adequately fulfill the increased coating demand. So this project will expand the SOFI area and will increase the production capability of the SOFI equipment.

Modifications at Building 303 involve moving the post-proof test X-ray facility from Building 103 to Building 303, adding staging and rework areas, and adding a 500,000 gallon demineralized water storage tank.

First, the post-proof test X-ray facility needs to be moved from Building 103 to Building 303 in order to improve production flow. The post-proof test X-ray process checks the LO_2 and the LH_2 tanks. Currently, after these tanks are assembled in Building 103 they are moved out to another building for proof testing, and then brough back to 103 for post-proof test X-ray. Bringing these tanks back into 103 interferes with manufacturing production flow in 103. To alleviate this interference, the post-proof test X-ray process will be moved to Building 303, which is located so that transport from the proof test building does not interfere with production flow.

Second, this relocation of the SOFI operation requires that staging and rework areas be added to Building 303 so that any defects found in the X-raying can be repaired without additional transport.

Third, the installation of a 500,000-gallon demineralized water storage tank is required to support the increased cleaning load. The demineralized water system is used in component cleaning operations in Building 103. The current system, however, is equipped for the production of only 18 ETs per year. To achieve the production of 24 ETs per year, an additional 500,000-gallon tank is required. This tank will be installed in Building 303 with a cross connector to the existing storage tank in Building 103.

All of these proposals are aimed at optimizing the production flow and increasing the production rate. Failure to approve this project would have prevented the production goal of 24 ETs per year.

2. CONSTRUCTION AND MODIFICATION TO SPACE SHUTTLE PAYLOAD FACILITIES, $12,000,000

A. CONSTRUCTION OF CARGO HAZARDOUS SERVICING FACILITY; KENNEDY SPACE CENTER: $9,000,000

This project provides for the construction of a facility at the KSC Industrial Complex for the servicing of hazardous cargo. There is a requirement to process large vertical class payloads which must have hypergol propellant loaded and drained, various ordnance systems installed, and other servicing/test/checkout conducted prior to being launched with the Space Shuttle. This proposed facility will provide the capability to adequately process and safely load propellants and explosive ordnance into the largest vertical class payloads that can fit in the STS Orbiter cargo bay. It will consist of an environmentally-controlled payload servicing cell equipped with dual cranes and will provide required servicing capability for the increasing numbers of large STS payloads.

Existing and presently planned payload processing facilities were inadequate in size and capability to provide for the large vertical class payloads that must be prepared for launch on the Shuttle at KSC. The new facility will be large enough to accommodate the multiuse mission support equipment transporter and canister. The proposed project will adequately and efficiently fulfill requirements for the increase in the size of the vertical payloads.

B. MODIFICATIONS TO SPACECRAFT ASSEMBLY AND ENCAPSULATION FACILITY (SAEF-2) FOR CARGO PROCESSING; KENNEDY SPACE CENTER: $3,000,000

This project modifies the Spacecraft Assembly and Encapsulation Facility (SAEF-2) to provide the necessary servicing and lift capability for Shuttle payloads weighing more than 10 tons, and upgrades the water supply system in order that the facility comply with the established criteria for processing and servicing of hazardous payloads.

KSC has no existing facility capable of servicing hazardous payloads weighing more than 10 tons. In order that the facility can process and service the necessary payloads of hypergol propellant weighing more than 10 tons, the existing SAEF-X cranes will be replaced by cranes with a 20-ton capacity. This modification will permit the hazardous servicing of a single payload which approaches the full size of the Orbiter's payload bay.

Likewise, SAEF-2 does not currently comply with the safety criteria for hazardous processing. Recent analyses have revealed that there is insufficient water volume and pressure to accommodate the fire protection requirements of SAEF-2 and five other nearby facilities. To upgrade the system to compliance standards, the project will install a separate ground level storage tank, pumping facility, and distribution system. To minimize cost, two 1,000 horsepower diesel-driven pumps will be relocated from Launch Complex 39 and a 1,000,000 gallon ground level storage tank will be relocated from the existing industrial area pumping station. Furthermore, an oxidizer waste tank with trench and drains for containing potential fuel spills and an emergency exhaust system with vents will be installed to upgrade the facilities safety. The drains, exhaust system, and electrical power system will also be made hazardproof.

Rejection or delay of this project would have placed unacceptable operational constraints on the efficiency of the STS payload processing in fiscal year 1985 and beyond.

3. CONSTRUCTION AND MODIFICATIONS AT JET PROPULSION LABORATORY, $4,300,000

A. CONSTRUCTION OF FREQUENCY STANDARDS LABORATORY: $2,700,000

This project provides for the construction of a frequency Standard Laboratory at the Jet Propulsion Laboratory (JPL). This proposed laboratory will create a center of developing advanced hydrogen maser timing devices.

Hydrogen masers are precision timing references required for planetary spacecraft navigation and science measurements. They are the primary timing references for the Deep Space Navigation (DSN). They are used in determining flight trajectory and navigational sequencing.

Present hydrogen master timing systems can achieve a 10^{-14} frequency stability. Very Long Baseline Interferometry (VLBI) navigation systems required by the Galileo missions, however, necessitate masers with 10^{-16} frequency stability. Likewise, science experiments such as gravity wave detection require 10^{-17} or better stability.

The present makeshift calibration facility at JPL, however, is inadequate for developing masers with the precision capabilities needed for these projects. Hydrogen masers are extremely sensitive to environmental disturbances. The single chamber of the existing facility is too small and cannot be environmentally controlled to the extent required for developing the more advanced masers.

The new laboratory facility will provide test areas with the required precisely controlled, disturbance free conditions, and sufficient capacity for long-term hydrogen maser calibration testing. It will consolidate the existing three separate and inadequate areas into the single new facility. This facility must be operational in 1985 to provide essential maser support to the DSN, expecially for the Galileo mission.

B. MODIFICATIONS TO SPACE FLIGHT OPERATIONS FACILITY: $1,600,000

This project provides for modifications to the Space Flight Operations Facility (SFOF) Building 230. These modifications will complete the enclosure of the fourth floor equipment level to protect against weather damage to both the building and the installed operational equipment, and will modify the heating, ventilating, and airconditioning (HVAC) systems for more reliable and efficient operation.

The SFOF is the operational center for all space flight control activities at JPL. This faility contains real time computers and operational equipment, and is the terminal for the NASA Deep Space Tracking Network and worldwide communications system. The computers and associated intrumentation must operate continuously in a closely controlled environment. Hence, an adequate and efficient HVAC system is requisite to the facility's operations.

In FY 1979 a central chiller plant was constructed to serve the SFOF Building 230 and its four additions. The chiller plant was connected to the existing air distribution equipment which is located on the partially enclosed fourth floor of building 230. Completion of the enclosure over the fourth floor equipment is necessary to provide improved safety conditions and weather protection for this equipment. This enclosure project will involve completing the siding and replacing the existing roofing surface.

Likewise, the major elements of the HVAC equipment have been in continuous operation for over 20 years and require major repairs or replacement. The new controls will be energy efficient and compatible with the utility control system.

Failure to approve this project will prolong the present inefficient and unreliable conditions and increase the risk of mission interruptions.

4. CONSTRUCTION OF FLUID MECHANICS LABORATORY; AMES RESEARCH CENTER, $3,900,000

This project provides for the construction of a fluid mechanics research laboratory at the Ames Research Center (ARC). The facility will house four small research wind tunnels and a laser research area with associated photographic darkroom.

A primary function of ARC is researching fundamental aerodynamics. This research is the foundation for advances in computational fluid dynamics, aircraft performances and rotorcraft technology, and aerodynamic test facility development. Fluid mechanics research at ARC has, however, been limited, and the center has focused on aerodynamic development. This restriction on fundamental research has resulted primarily because the existing wind tunnels are large, which makes power requirements and model cost high.

The four wind tunnels housed in the proposed facility will be small and appropriate for research activities. The cost of models for use in these small tunnels will rarely exceed $5,000, while models for the larger tunnels can exceed $1,000,000. Moreover, one of the four research tunnels is equipped with an adaptive wall, which allows the test area of the tunnel to be adjusted to approximately the shape of the streamline of the air flow over the model being tested. This capability is expected to eliminate or reduce data inaccuracies caused by air flow waves. The concept can also be applied to the larger tunnels once it has been tested and improved in the small tunnels. Because of their small size and modular construction, modification of these tunnels for special experiments or improved technology applications will be simple and inexpensive.

The small photographic darkroom and laboratory space for laser research will also serve in the research of fluid mechanics. Nonintrusive laser diagnostics, already in use, will be further studied in this laboratory. This technique offers the possibility of highly accurate air flow measurements and more through understanding of complex fluid mechanics.

None of the four tunnels will be funded by this project; two will be provided for with research funds, and the other two are already located in makeshift space with insufficient room for research and support activities, and they need only be relocated.

Failure to approve or delay of this concept will result in NASA being unable to take advantage of recent concepts in wind tunnel technology and instrumentation in a timely manner.

5. CONSTRUCTION OF AN AERONAUTICAL TRACKING FACILITY; DRYDEN FLIGHT RESEARCH FACILITY, $800,000

This project provides for the construction of an Aeronautical Tracking Facility (ATF) at the Dryden Flight Research Facility (DFRF), a component of the Ames Research Center. The primary mission of DFRF is to conduct aeronautical flight research and provide long-term Space Shuttle support. The Aeronautical Test Range at DFRF is currently used extensively in support of priority national defense programs and technological advancements directly applicable to the commercial aviation industry which is experiencing strong foreign competition. NASA and the Air Force cooperate to support the testing needs of both organizations, and under this arrangement NASA is responsible for the operation and maintenance of the test range.

Currently, this test range is equipped with only one aeronautical tracking system and no backup. A 40% growth in the number of flight test and a 30% increase in the average flight duration over the past 2 years has forced the single ATF to operate at its maximum capability of supporting 400 flights per year. The future increases in flight tests, however, will require an ATF with the capability to handle approximately 800 flights per year. In order to provide this tracking capability, a facility is needed to accommodate the additional antennas, antenna electronics, and communication components. This facility must be sited at a remote area of DFRF to provide line-of-sight radio frequency communication paths to the aircraft operational areas, Edwards AFB north facilities and remote desert test corridors. The facility is needed by FY 1984 in order to provide the tracking capability required by the increase in test flights.

6. MODIFICATIONS TO LANGLEY RESEARCH CENTER, $9,500,000

A. MODIFICATIONS AND ADDITION FOR COMPOSITE MATERIALS LABORATORY, BUILDING 1293A AT LANGLEY RESEARCH CENTER: $5,100,000

This project provides for an addition to and modification of Building 1293A and the installation of a data link from Building 1293B to the Data Reduction Center at the Langley Research Center (LaRC). The addition to Building 1293A will house an advanced composites processing laboratory on the first floor and new polymer research laboratories on the second. Modifications to Building 1293A will involve restoring the existing laboratory space into offices and refurbishing the heating, ventilating, and air conditioning (HVAC) system.

LaRC is responsible for the development and application of advanced composite materials for aircraft and spacecraft, and for research on the control and dynamics of large spacecraft structures. Technology in these areas has high potential for reducing the fabrication cost in spacecraft and aircraft. Further research is required to develop both the materials and the processes to the level needed to replace the current thermosetting resin systems now in use.

The 15 year old laboratories in which such research is currently conducted, however, have deteriorated to the point that research cannot be safely or efficiently conducted. The research is now performed at scattered sites within Building 1148 nand 1293A. To aggravate this inconvenience, the fume hood and venting systems are severely corroded and are extremely inefficient because they draw building air and this increases the load on the HVAC system. Also, fresh air intakes for the HVAC system are not adequately separated from the venting system, therefore allowing noxious fumes from the processing area to sometimes cycle throughout the building.

Likewise, the data link from Building 1293B to the Data Reduction Center is needed to improve the monitoring capability for the test performed on large space structures. These structures are being developed for various applications such as general purpose platforms and antennas. In order to test the dynamics of these structures, the control parameters and points need to be monitored or interactively varied during the test. By linking the laboratory into the LaRC central computers this monitoring capability will be improved ten-fold.

Any significant increase in the use of composites on future aircraft is dependent on improvements in the materials and processes, and these improvements cannot be developed without the adequate laboratory facilities which this project provides.

B. MODIFICATIONS TO 30-BY-60-FOOT WIND TUNNEL; LANGLEY RESEARCH CENTER: $4,400,000

This project provides for modifications to the 30-by-60-foot wind tunnel at LaRC. The modifications involve replacements and repairs to the turntable and model support system, control room modifications, and automation of tunnel controls.

This wind tunnel is the only facility in the United States capable of free-flight test of models at subsonic speeds. This allows for the research of the flight aspects of low speed, highly maneuverable aircraft. Moreover, the capability of free-flight testing helps identify and define critical test regions and parameters for additional fixed aerodynamic testing. It also provides greater insight into unexpected or otherwise unexplainable problems which would not be discovered until actual flight test. Because the tunnel is equipped with an open-throat test section, research engineers and pilots can be strategically placed to best obtain data and control the aircraft model. More importantly, this feature permits the model to be removed from the airstream in the event of a control malfunction, which eliminates damage or destruction to the model (typically costing up to $500,000).

The turntable and model support systems of this tunnel have, however, been in operation since 1956, and require extensive repair and updating. The worn parts contribute to excessive relative motion of the test aircraft, and cause many man-hours to be consumed in error investigation and corrective procedures. Furthermore, the facility now has a backlog in excess of 2 years, and current increased emphasis on improved low-speed performance for military aircraft will create additional demands.

To solve both the problem of the worn support system and the backlog, this project will replace the model support and balance system, eliminating the time consuming task of calculating for motion error, and will update the control room. These modifications will increase the productivity and efficiency of operation and will improve the quality of data obtained.

Any delays in this project will compromise LaRC's ability to respond to current requirements for high-performance military aircraft with greatly improved low-speed stability and performance, and would result in continued deterioration of the model support system and increase the chance of a major failure that could result in serious injury to personnel and/or destruction of the test vehicle.

7. MODIFICATIONS TO LEWIS RESEARCH CENTER, $10,600,000

A. MODIFICATIONS FOR SMALL ENGINE COMPONENT TESTING FACILITY: $7,000,000

This project provides for modifications to Building 5 of the Engine Research Building Complex at Lewis Research Center (LeRC). The modifications allow for the establishment of research and testing areas and the installation of associated testing equipment for researching the compressors and turbines on small gas turbine engines. Test cell CE-18 will be modified for compressor research, and test cell CE-17 will be modified for turbine research.

This research is necessary to improve the overall performance and efficiency of small gas turbine engines. These engines are used for an increasing variety of aircraft and ground power applications, such as small aircraft, cruise missiles, trucks, and buses. Difficult geometric problems such as compressor and turbine blade clearances, surface finishes, and leading and trailing edge thicknesses have, however, kept the performance and efficiency of these small engines substantially lower than that of larger turbine engines.

Test facilities needed to research these problems do not presently exist. The nonlinear nature of the fluid and structural mechanics of turbine engines makes scaled down large component research data inaccurate for small engine application. Moreover, the compressor testing equipment at LeRC does not provide the full range of operating conditions needed to conduct comprehensive research. And the existing turbine testing facilities are also inadequate because only overall performance data can be obtained, while controlled internal flow and studies of the ratios of actual turbine inlet to coolant temperatures cannot be measured.

Test capabilities provided by this project will eliminate the inadequacies of the present facilities. No comparable facility exist within NASA, government agencies, or industry. This facility is requisite to developing improvements in the design of small turbine engines. And these improvements can significantlky contribute to the Nation's energy conservation and environmental protection efforts, as well as to maintaining world-wide aeropropulsion preeminence.

B. MODIFICATIONS TO ICING RESEARCH TUNNEL: $3,600,000

This project provides for modifications to the Icing Research Tunnel (IRT) at Lewis Research Center. The modifications involve upgrading the tunnel utilities, test chamber, and office-shop building. The modifications are required to insure that the reliability and capability of this 40-year old tunnel are maintained and enhanced to meet present demands.

The IRT is the largest icing tunnel in the United States and the only tunnel capable of testing certain full-scale components. Heavy use of the tunnel has produced a 2-year backlog. Furthermore, recent studies have revealed a greater need for icing research in support of commercial, general aviation, and military aircraft. So basic icing research, developments in systems, and new aircraft designs will demand the use of this tunnel.

The provisions in this project will provide the tunnel with a wider range of test conditions, improve control of the tunnel's operating conditions, and increase the efficency of operating the tunnel. Also, the quality and research value of the data obtained from tunnel test will be improved by enhancing the realism of the test conditions.

Failure to approve this project will only contribute to additional testing backlog, and will increase the risk of a major breakdown, such as occurred in April of 1982 and required the shut down of the tunnel for 3 months.

8. RELOCATION OF 26-METER STDN ANTENNA, SPAIN, $1,700,000

This project relocates the 26-meter Spaceflight Tracking and Data Network (STDN) antenna from Fresnedillas, Spain, to the main Deep Space Network (DSN) complex in Robledo, Spain. This project is part of the plan to consolidate all required antenna facilities in the Madrid, Spain area at one central location. The relocation will allow for the closure of the remote STDN station at Fresnedillas, Spain and thereby save $2.5 million annually.

The DSN is necessary to support certain earth-orbital missions, such as spacecraft in highly ellipitical or geosynchronous orbits, which cannot be tracked by the new Tracking and Data Rely Satellite System. Also the DSN will serve as an emergency back-up system.

The cost of relocating this antenna will be returned in the operational savings in the first year. The antenna is needed for the 1985 Voyager-Uranus encounter, so the relocation cannot be in process during FY 1985. Failure to approve this project now will thus postpone the relocation until FY 1986, and forfeit the $2.5 million annual saving for an unnecessary 2 years.

9. REPAIR OF FACILITIES AT VARIOUS LOCATIONS, $19,500,000

These resources will provide for large repairs to facilities at NASA's field installations and Government-owned industrial plants supporting NASA activities. Repair is defined as restoring facilities to a condition substantially equivalent to their originally intended and designed capability. This program provides for repair work that has an estimated cost not in excess of $500,000 per project, and the work is of such a nature and magnitude that it cannot be accomplished by routine day-to-day facility maintenance and repair activities, or by related routine facility work efforts that are provided for in other than CoF estimates.

A major portion of the Agency's buildings exceed 15 years in age, and increases in repair requirements are to be expected. Maintenance and repair costs for mechanical and electrical systems in a typical building are almost three times higher during the 16- to 30-year range period of a building's life than they are during the initial 15 years. At about the 15-year point, many electrical and mechanical components reach the end of their serviceable or economic life and should be replaced in the interest of long-term economy. Continued piecemeal repair of these components usually requires more resources in the long run than replacement after the end of the economic life of the original components.

The major thrust of this repair program, as well as the rehabilitation and modification program, is to preserve the Agency's $7.7 billion capital type property of which the physical plant comprises $3.2 billion. Some 75% of the physical plant is in the 16- to 30-year old range.

Furthermore, this repair program has been distilled from requests for FY 1984 exceeding $25,800,000. Those projects with the highest priority requirements, based on relative urgency and expected return on investment, comprise this program. Thus, the program represents a modest request in relation to the continuing backlog of this type of work. Deferral of this mission-essential work would adversely impact the availability of critical facilities and program schedules, and would increase the risk of breakdowns and costly emergency repairs.

During the course of the year, it is recognized that some rearrangement of priority may be necessary. This may force a change in some of the items to be accomplished. Any such change, however, will be accomplished within available resources.

Project Cost Estimates

Utility Systems	$9,320,000
General Purpose Buildings	1,255,000
Technical Buildings/Structures	5,550,000
Pavements and Drainage	1,295,000
Building Exteriors and Roofs	2,080,000

Summary of Project Amounts by Location

Ames Research Center	$1,395,000
Dryden Flight Research Center	425,000
Goddard Space Flight Center	1,690,000
Jet Propulsion Laboratory	1,740,000
Johnson Space Center	1,440,000
Kennedy Space Center	410,000
Langley Research Center	3,310,000
Lewis Research Center	2,280,000
Marshall Space Flight Center	2,265,000
Michoud Assembly Facility	1,765,000
National Space Technology Laboratories	1,525,000
Wallops Flight Facility	230,000
Various Locations	680,000
Miscellaneous Projects Not Exceeding 150,000 Each	345,000
Total	19,500,000

10. REHABILITATION AND MODIFICATION OF FACILITIES AT VARIOUS LOCATIONS, $24,500,000

These resources will provide for the rehabilitation and modification of facilities at NASA field installations and Government-owned industrial plants supporting NASA activities. Included in this request are those facility rehabilitation and modification needs for fiscal year 1984 that have been fully identified at the time of the submission of these estimates, and that are estimated not to exceed $500,000 per project. Likewise, the work is of such a nature and magnitude that it cannot be accomplished by routine day-to-day facility maintenance or by related routine facility work efforts that are provided for in other than CoF estimates.

These rehabilitations and modifications are required to: (A) Protect the capital investment in these facilities by minimizing the cumulative effects of wear and deterioration. (B) Ensure that these facilities are continuously available and that they operate at peak efficiency. (C) Improve the capabilities and usefulness of obsolescence. (D) Provide a better and safer environment for all personnel. (E) Provide significant reductions in energy consumption through the institution of energy conservation projects including improved utility control systems.

The program request of $24,500,000 has been distilled from requests of approximately $32,300,000 and represents only a modest request in relation to the backlog of this type of work. The projects which comprise this request are the highest priority requirements, based on relative urgency and expected return on investment. Deferral of this mission-essential work would adversely impact the availability of critical facilities, program schedules, and energy conservation objectives.

During the course of the year, some rearrangment of priorities may be necessary. This may force a change in some of the items to be accomplished. Any such change will be accomplished within available resources.

Project Cost Estimates

Utility Systems	$5,360,000
Fire Detection/Protection Systems	2,805,000
General Purpose Buildings	4,890,000
Technical Buildings/Structures	10,835,000
Building Exteriors and Roofs	610,000

Summary of Project Amounts by Location

Ames Research Center	$2,205,000
Dryden Flight Research Facility	845,000
Goddard Space Flight Center	2,135,000
Jet Propulsion Laboratory	1,980,000
Johnson Space Center	2,200,000
Kennedy Space Center	1,455,000
Langley Research Center	2,495,000
Lewis Research Center	3,145,000
Marshall Space Flight Center	2,445,000
Michoud Assembly Facility	925,000
National Space Technology Laboratories	1,375,000
Wallops Flight Facility	1,535,000
Various Locations	1,310,000
Miscellaneous Projects Not Exceeding $150,000 Each	450,000
Total	24,500,000

11. MINOR CONSTRUCTION OF NEW FACILITIES AND ADDITIONS TO EXISTING FACILITIES AT VARIOUS LOCATIONS, $4,800,000

These resources will provide for minor facility construction at NASA field installations and Government-owned industrial plants supporting NASA activities. Each project included in this program is estimated to cost not more than $250,000 and involves either the construction of new facilities or additions to facilities. This program will improve the usefulness of NASA's physical plant by changing the utilization of or augmenting the capabilities of various facilities.

The configuration of NASA's physical plant necessarily must respond to changes in utilization and adaptations required by changes in technology or in mission needs. Demands are generated by research, development, test, and similar activities.

Those facility projects for institutional or technical facility needs which could be fully identified at the time of submission of this budget estimate are included in this program. Items of work totalling $4,800,000 are included in this resource request and have been distilled from a list totaling over $6,600,000. Projects were selected on the basis of the relative urgency of each item and the expected return on the investment. During the course of the year, rearrangement of priorities may require changes in some of the items to be accomplished. Such changes will be accommodated within the resources allocated.

Cost Distribution by Work Category

Utility Systems	$615,000
General Purpose Buildings	1,620,000
Technical Buildings/Structures	2,330,000
Pavements and Drainage	235,000

Summary of Project Amounts by Location

Ames Research Center	$460,000
Dryden Flight Research Facility	230,000
Goddard Space Flight Center	680,000
Jet Propulsion Laboratory	865,000
Kennedy Space Center	475,000
Langley Research Center	760,000
Lewis Research Center	440,000
Marshall Space Flight Center	200,000
National Space Technology Laboratories	490,000
Various Locations	200,000
Total	4,800,000

12. FACILITY PLANNING AND DESIGN, $9,200,000

Regular Requirements	$6,950,000
Other Requirements	2,250,000

The funds requested in this estimate are required to provide for advance planning and design activities related to the construction and modification of facilities. These planning and design activities involve the following;

(a) The accomplishment of necessary development and master planning.

(b) The preparation of preliminary engineering reports, cost estimates, and design and construction schedules.

(c) The preparation of final construction plans, specifications, and associated cost estimates and schedules.

(d) The accomplishment of facilities siting and other investigation studies and reports.

The activities listed under "Regular Requirements" encompass the basic purposes outlined above. The activities listed under "other requirements" cover those projects, such as the Shuttle, Spacelab, and Payload initiatives, which are large and complex and necessitate that design activities begin earlier than for regular projects. These large projects require more planning and longer lead time than is normally involved.

Regular Requirements	$6,950,000
Master Planning	200,000
Sustaining Engineering Support	450,000
Preliminary Engineering Reports and related Special Engineering Support	2,300,000
Final Design	4,000,000

a. *Master Planning.* $200,000

These funds provide for the updating and further development of existing master plans for NASA's field installations. These plans are generally updated at cyclic 4-year intervals. Approximately one-fifth of the field installations are involved in any one year. Candidates for FY 1984 are Langley Research Center and Goddard Space Flight Center.

b. *Sustaining Engineering Support.* $450,000

Funds from this program provide for the study of various aspects of NASA's facility construction activities. These studies address such construction and operating factors as: cost trends in construction materials and fuels; the importance of energy conservation and efficiency; and the operation and maintenance for physical plants.

The specific areas of study which will be included in the FY 1984 requirements are:

1. Building Research Advisory Board Support
2. Utilities Services/Rates Analysis
3. Facility Operation and Maintenance Analysis
4. Value Engineering Cost Validations and Analyses
5. Facilities Utilization Analyses
6. Environmental Studies.

c. *Preliminary Engineering Reports and Related Special Engineering Support.* $2,300,000.

1. Preliminary Engineering Reports (PER's). $1,800,000.

PER's are responsible for investigating and studying facility projects proposed for the FY 1986 and FY 1987 budgets. These reports permit the early and timely development of the most suitable projects and see that these projects meet their stated functional need.

2. Related Special Engineering Support. $500,000.

These funds provide for the investigation and project study of programs which are proposed in this FY 1984 Construction of Facilities Budget Estimate. These studies are conducted as the project is being accomplished and allow for the timely development of the projects while insuring that the projects meet their stated functional need. Likewise, these studies also provide basic data, cost estimates, and schedules for future projects in related areas.

d. *Final Design.* $4,000,000.

The amount requested will provide for the preparation of designs, plans, drawings, and specifications necessary for the accomplishment of projects other than Space Shuttle, Spacelab and Payloads initiatives. Projects involved with this program are planned for inclusion in the FY 1985 and FY 1986 budgets.

The request will provide for final design work associated with construction proposed for the FY 1985 Program, estimated to cost $55 to $60 million, and for $8 to $12 million of high potential projects proposed for the FY 1986 program.

Other Requirements	$2,250,000
A. Space Shuttle Facility Planning and Design	1,350,000
B. Payload Facility Planning and Design	900,000

A. *Space Shuttle Facility Planning and Design.* $1,350,000.

These resources provide for early and progressive design work, final drawings, specifications, and site investigations for future Space Shuttle facilities in order to insure the best design, good cost estimates, and realistic construction schedules. The Shuttle operational era requirements include expansion of Kennedy Space Center vehicle processing facilities to meet an increasing launch rate, construction of operations personnel facilities, modifications to the launch complex, modifications at various locations for space engine testing, and additional facilities to support external tanks and other production facilities.

B. *Payload Facility Planning and Design.* $900,000.

Support of the operational phase of the STS payloads processing program will necessitate preparation of Preliminary Engineering Reports, facility site investigations, design of facility projects, and studies to determine facility capabilities. Included are Johnson Space Center facilities for payload static/dynamic testing and crew simulation facilities, expansion of Kennedy Space Center facilities to conduct cargo hazardous servicing and payload processing for the larger and more numerous payloads, as well as facilities projects for logistics and maintenance of payloads and storage of associated flight and support equipment.

RESEARCH AND PROGRAM MANAGEMENT, $1,242,500,000

SUMMARY OFBUDGET PLAN BY FUNCTION

Personnel and related costs	$883,785,000
Travel	25,700,000
Operation of installation	338,015,000
General reduction	5,000,000
Total	1,242,500,000

The Research and Program Management appropriation funds the performance and management of research, technology and test activities at NASA installations, and the planning, management and support of the many and varied contractor research and development tasks necessary to meet the Nation's ongoing objectives in aeronautical and space research. Objectives of the efforts funded by the Research and Program Management appropriation are to (1) provide the technical and management capability of the civil service staff needed to conduct the full range of programs for which NASA is responsible, (2) maintain facilities and laboratories in a state of operational capability and manage their use in support of research and development programs, and (3) provide effective and efficient technical and administrative support for the research and development programs. For 1984, an appropriation of $1,242,500,000 is requested.

The 21,219 dedicated civil service personnel at eight major installations and Headquarters are funded by the Research and Program Management appropriation. This civil service workforce is NASA's most important resource and is vital to future space and aeronautics research activities. Seventy percent of the Research and Program Management appropriation is needed to provide for salaries and related costs of this civil service workforce. About two percent is for travel, vital to continue to manage successfully the Agency's in-house and contracted programs. The remaining amount of the Research and Program Management appropriation provides for the research, test and operational facility support, and for related goods and services necessary to operate the NASA installations and to accomplish NASA's approved missions efficiently and effectively.

NASA field centers report to the Program Associate Administrator responsible for the major portion of their technical program. The principal roles of fundamental importance assigned each of the eight NASA installations based on demonstrated capabilities and capacities to meet NASA's overall program goal are as follows:

Office of Space Flight

Johnson Space Center: Manage the integrated Space Shuttle program, including Orbiter production and operation; astronaut and mission specialist selection and training; STS Operations including mission planning, operational procedures and flight control; and application of remote sensing to agricultural assessments and other Earth resources uses.

Kennedy Space Center: Launch of Space Shuttle flights; the ground operational phase of the Space Transportation System; and the preparation and launch of payloads on the Space Shuttle and expendable launch vehicles.

Marshall Space Flight Center: Manage the Space Shuttle main engine, solid rocket booster and external tank projects; management of NASA's activities on the Spacelab project; management of large automated spacecraft projects such as the Space Telescope; and experiments in materials processing in space.

National Space Technology Laboratories: Support Space Shuttle engine procurement and testing; regional Earth resources research and technology transfer; and support functions for other Government agencies located there.

Office of Space Science and Applications

Goddard Space Flight Center: Develop and operate the Earth orbital flight experiments and automated spacecraft to conduct scientific investigations and demonstrate practical applications; the management of the tracking and data acquisition activities for Earth orbital missions; management of the Delta launch vehicle program; management and launch of sounding rockets and balloons; and operation of an instrumented flight range for aeronautical and space research. The Wallops Facility is an operational element and component installation of the Goddard Space Flight Center.

Office of Aeronautics and Space Technology

Ames Research Center: Develop short haul aircraft and rotorcraft research and technology, computation fluid dynamics, planetary probe research, life sciences, aeronautical flight research and testing, as well as providing a contingency landing site for Space Shuttle operational missions at the Dryden Flight Research Facility, an operational element and component installation of Ames.

Langley Research Center: Develop long haul aircraft research and technology, emphasizing fuel conservation, safety and environmental effects; aerospace structures technology; environmental quality monitoring by remote sensing; and advanced space systems technology.

Lewis Research Center: Develop and maintain aeronautical and space propulsion research and technology; space communications research and technology; space energy systems research and technology; and development of the Centaur Stage for use in the Space Shuttle and management of the Centaur expendable launch vehicle program.

The 1984 budget provides the necessary resources to apply these in-house capabilities to program activities. A summary description of, and the funding required by functional category, include:

PERSONNEL AND RELATED COSTS, $883,785,000

COMPENSATION AND BENEFITS

1. Compensation

a. Permanent Positions: This part of Personnel and Related Costs covers the salaries of the full-time permanent civil service workforce and is the largest part of the functional category. As noted above, the 1984 funds will provide for 21,219 full-time permanent civil service employees.

b. Other Than Full-Time Permanent Positions: This category includes the salaries of NASA's non-permanent workforce. Programs such as students participating in cooperative training, summer employment, youth opportunity, and temporary clerical support are covered in this category.

c. Reimbursable Detailees: In accordance with existing agreements, NASA reimburses the parent Federal organization for the salaries and related costs of persons detailed to NASA.

d. Overtime and Other Compensation: Overtime, holiday, post and night differential, and hazardous duty pay are included in this category. Also included are incentive awards for outstanding achievement and superior performance awards.

2. Benefits

In addition to compensation, NASA makes an employer's contribution to personnel benefits as authorized and required by law. These benefits include contributions to the Civil Service Retirement Fund, employees' life and health insurance, and social security contributions for non-permanent personnel. Payments for severance pay are made to former employees involuntarily separated through no fault of their own. Beginning 1983, the cost of NASA's matching contribution for Medicare is included.

SUPPORTING COSTS

1. *Transfer of Personnel:* Relocation costs, such as the expenses of selling and buying a home, and the movement and storage of household goods are provided under this category.

2. *Office of Personnel Management Services:* The Office of Personnel Management is reimbursed for certain activities such as security investigations on new hires, recruitment advertising, and career-maturity surveys.

3. *Personnel Training:* Training is provided within the framework of the Government Employees Training Act of 1958. Part of the training costs consist of courses offered by other Government agencies, and the remainder provides for training through nongovernment sources.

TRAVEL, $25,700,000

Program Travel

The largest part of travel is for direction, coordination and management of program activities including international programs and activities. The complexity of the programs involved and the geographical distribution of NASA installations and contractors throughout the entire United States impose the requirement for this category of travel. As projects reach the flight stage, support is required for prelaunch activities, including overseas travel to launch and tracking sites. The amount of travel required for flight projects is significant as it is directly related to the number of systems and subsystems, the number of design reviews, and the number and complexity of the launches and associated ground operations.

Scientific and Technical Development Travel

Travel to scientific and technical meetings and seminars permits employees engaged in research and development to participate at both Government-sponsored and nongovernment-sponsored seminars. This participation allows personnel to benefit from exposure to technological advances which arise outside NASA, as well as allowing personnel to present both accomplishments and problems to their associates and provide for the dissemination of technical results to the U.S. community. Many of the Government-sponsored meetings are working panels convened to solve certain problems for the benefit of the Government.

Management and Operations Travel

Management and operations travel includes travel for the direction and coordination of general management matters and travel by officials to review the status of programs. It includes travel by functional managers in such areas as personnel, financial management and procurement. This category also includes the cost of travel in and around the Installations; travel of unpaid members of research advisory committees; and initial duty station, permanent change of assignment, and other family travel expenses. Payments to interagency motor pools are included in the Operation of Installation function (Management and Operations subfunction).

OPERATION OF INSTALLATION, $338,015,000

FISCAL YEAR 1984 BUDGET PLAN

Facility Services	$186,488,000
Technical Services	59,257,000
Management and Operations	92,270,000
Total	338,015,000

Operation of Installation provides a broad range of services, supplies, and equipment in support of the centers' institutional activities. These are divided into three major subfunctional areas: Facilities Services (the cost of renting real property, maintaining and repairing institutional facilities and equipment, and the cost of custodial services and utilities); Technical Services (the cost of automatic data processing for management activities, and the cost of educational and information programs and technical shops supporting institutional activities); and Management and Operations (the cost of administrative communications, printing, transportation, medical, supply, and related services). A description of each major subfunction follows:

Facilities Services

1. Rental of Real Property: Rental of real property includes the rental of building space directly by NASA or through the General Services Administration to meet offsite office, warehousing, and other requirements which cannot otherwise be provided in existing buildings at the NASA Installation. Most of the funding is required for rental of the NASA Headquarters complex of buildings in the District of Columbia, and nearby Maryland and Virginia that are either Government-owned or leased for which NASA must provide rental payments to the General Services Administration in accordance with P.L. 92-313. Also included in this item is rental of trailers required to accommodate special short-term needs.

2. Maintenance and Related Activities: Maintenance and related activities includes the recurring day-to-day maintenance of facilities (ground, buildings, structures, etc.) and equipment which is accomplished by non-Civil Service personnel. This involves the mowing and care of grassy areas, care of trees and shrubs, elevators, cranes, pressure vessel inspections, painting and protective coatings, general buildings maintenance, and the maintenance of installed mechanical, electrical, and other systems. In addition, this item includes feasibility studies, project design, construction supervision, inspection, and other institutional facility engineering functions. Included also are any applicable costs associated with recurring facility work as well as materials, hardware, and equipment used in facility maintenance activities, whether accomplished by civil service personnel or contractors. In the cost of equipment, related maintenance and other services are reflected for office, shop, laboratory and other facilities equipment as well as administrative internal communications and television monitoring equipment.

3. Custodial Services: Custodial services include janitorial and building cleaning services, pest control, fire protection services, security services including badging and identification, lock and safe repair, trash and refuse handling, window blinds and light fixture cleaning, and laundry and dry cleaning of facility related items.

4. Utilities Services: Utilities services include the purchase of utilities such as electricity, natural gas, fuel oil, coal, steam, propane, and other fuel commodities as well as water and sewage treatment services. Also included are the related maintenance and operating costs of the utility plants and systems.

Technical Services

1. Automatic data processing

a. Equipment: This category provides for the lease, purchase and maintenance of general purpose data processing equipment which supports institutional operations at each installation. Excluded is equipment dedicated to specific research or operational systems which is funded from the Research and Development appropriation.

b. Operations: Operations services include programming, computer operations and related services for institutional applications including payroll, financial management, security, maintenance, personnel, logistics, and procurement records and reports.

2. Scientific and technical information and educational programs

a. Libraries: The technical libraries are established to provide installation staffs with books, periodicals, technical reports and other documentation.

b. Education and Information Programs: The educational and informational programs provide for the documentation and dissemination of information about the Agency's programs to the general public, the educational community at the elementary and secondary levels, and the mass communications media. Assistance to the mass communications media includes the assembly and exposition of newsworthy material in support of requests in the form of press kits, news releases, television and radio information tapes and clips, and feature material.

c. Shop and Support Services: Shop and support services include general fabrication shops, reliability and quality assurance activities, safety, photographic services, graphics, and audio-visual material.

Management and Operations

1. Administrative Communications: Included in this category are costs of leased lines not dedicated to a specific program or project, long distance tolls, teletype services, and local telephone service.

2. Printing and Reproduction: Included in this category are the costs for duplicating, blueprinting, microfilming, and other photographic reproductions. Also included in this category are Government Printing Office printing costs, contractual printing and the related composition and binding operations.

3. Transportation: Transportation services include the operation and maintenance of all general purpose motor vehicles used by both civil service and support contractor personnel. The cost of movement of supplies and equipment by commercial carriers and payments to interagency motor pools are also in this category.

4. Installation Common Services: Installation common services include support activities at each installation such as: occupational medicine and environmental health; mail service; supply management; patent services; administrative equipment; office supplies and materials; and postage.

FISCAL YEAR 1984 NASA CIVIL SERVICE EMPLOYEE DISTRIBUTION

	Kennedy	Johnson	Marshall	Goddard	Ames	Langley	Lewis	NSTL	Hq.	Total	JPL [1]
Space transportation:											
Space transportation capability development	351	1,432	809	25		6	115	5	143	2,886	6
Space transportation operations	1,086	1,059	750	110	32	26	45		51	3,159	9
Space science and applications:											
Physics and astronomy	107	11	756	1,015	117				65	2,071	87
Planetary exploration		26		79	57				26	188	717
Life sciences	4	97	1	3	125	6			33	269	27
Space applications	2	96	264	801	54	182	129	40	91	1,659	361
Technology utilization	5	4	6	5	3	9	1		13	46	4
Aeronautics and space technology:											
Aeronautical R&T		5	6	21	1,001	1,415	1,219		73	3,740	7
Space R&T	12	34	173	101	143	528	372		49	1,412	206
Energy technology										0	
Tracking and data acquisition				708	28				54	790	500
Subtotal direct	1,567	2,764	2,765	2,868	1,560	2,172	1,881	45	598	16,220	1,924
Center management operations	545	529	520	755	461	673	598	59	859	4,999	1,029
Total	2,112	3,293	3,285	3,623	2,021	2,845	2,479	104	1,457	21,219	3,424

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[1] JPL is staffed by Cal Tech. The entire cost is borne by the R&D appropriation. Personnel numbers are shown here for comparison only.

TITLE II: NOAA LANDSAT AUTHORIZATION

Section 201 authorizes the appropriation to the Secretary of Commerce of $29,336,000 for operating Landsat 4 and storing Landsat D′. It is anticipated that an additional $16,000,000 will be needed to meet operational costs and that these funds will be transferred to the Department of Commerce from other agencies—thus they are not authorized here. The amount authorized includes storage costs of $5,800,000.

Section 202 puts limitations on the authority of the Secretary of Commerce to transfer the ownership or operation of any civil remote sensing satellites—land, weather, or ocean—to the private sector. The Secretary may not make such a transfer unless (1) he submits a comprehensive statement of recommended policies, procedures, conditions, and limitations to which any transfer should be subject; and the Congress thereafter enacts into law such policies, procedures, conditions or limitations as it deems appropriate for such transfer.

SECTIONAL ANALYSIS

OF A BILL TO AUTHORIZE APPROPRIATIONS TO THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION FOR RESEARCH AND DEVELOPMENT, CONSTRUCTION OF FACILITIES, AND RESEARCH AND PROGRAM MANAGEMENT, AND FOR OTHER PURPOSES.

TITLE I

Section 101

Subsections (a), (b), and (c) would authorize to be appropriated to the National Aeronautics and Space Administration funds, in the total amount of $7,268,220,000, as follows: (a) for "Research and development," a total of 10 program line items aggregating the sum of $5,886,800,000; (b) for "Construction of facilities," a total of 15 line items aggregating the sum of $138,920,000; and (c) for "Research and program management," $1,242,500,000. Subsection (c) would also authorize to be appropriated such additional or supplemental amounts as may be necessary for increases in salary, pay, retirement, or other employee benefits authorized by law.

Subsection 101(d) would authorize the use of appropriations for "Research and development" without regard to the provisions of subsection *101(g)* for: (1) items of a capital nature (other than the acquisition of land) required at locations other than NASA installations for the performance of research and development contracts; and (2) grants to nonprofit institutions of higher education, or to nonprofit organizations whose primary purpose is the conduct of scientific research, for purchase or construction of additional research facilities. Title to such facilities shall be vested in the United States unless the Administrator determines that the national program of aeronautical and space activities will best be served by vesting title in any such grantee institution or organization. Moreover, each such grant shall be made under such conditions as the Administrator shall find necessary to insure that the United States will receive benefit therefrom adequate to justify the making of that grant.

In either case, no funds may be used for the construction of a facility in accordance with this subsection, the estimated cost of which, including collateral equipment, exceeds $225,000, unless the Administrator notifies the Speaker of the House, the President of the Senate and the specified committees of the Congress of the nature, location, and estimated cost of such facility.

Subsection 101(e) would provide that, when so specified and to the extent provided in an appropriation act, (1) any amount appropriated for "Research and development" or for "Construction of facilities" may remain available without fiscal year limitation, and (2) contracts for maintenance and operation of facilities, and support services may be entered into under the "Research and program management" appropriation for periods not in excess of twelve months beginning at any time during the fiscal year.

Subsection 101(f) would authorize the use of not to exceed $35,000 of the "Research and program management" appropriation for scientific consultations or extraordinary expenses, including representation and official entertainment expenses, upon the authority of the Administrator, whose determination shall be final and conclusive.

Subsection 101(g) would provide that of the funds appropriated for "Research and development" and "Research and program management," not in excess of $75,000 per project (including collateral equipment) may be used for construction of new facilities and additions to existing facilities, and for repair, rehabilitation, or modification of facilities.

Section 102

Section 102 would authorize upward variations of the sums authorized for the "Construction of facilities" line items (other than facility planning and design or for reimbursement to the General Services Administration for space utilized at Ellington Air Force Base) of 10 percent at the discretion of the Administrator or his designee, or 25 percent following a report by the Administrator or his designee to the Committee on Science and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate on the circumstances of such action, for the purpose of meeting unusual cost variations. However, the total cost of all work authorized under these line items may not exceed the total sum authorized for "Construction of facilities" under subsection 101(b), paragraphs (1) through (16).

Section 103

Section 103 would provide that not more than one-half of 1 percent of the funds appropriated for "Research and development" may be transferred to and merged with the "Construction of facilities" appropriation and, when so transferred, together with $10,000,000 of the funds appropriated for "Construction of facilities," shall be available for the construction of facilities and land acquisition at any location if the Administrator determines (1) that such action is necessary because of changes in the aeronautical and space program or new scientific or engineering developments, and (2) that deferral of such action until the next authorization act is enacted would be inconsistent with the interest of the Nation in aeronautical and space activities. However, no such funds may be obligated until 30 days have passed after the Administrator or his designee has transmitted to the Speaker of the House, the President of the Senate and the specified committees of Congress a written report containing a description of the project, its cost, and the reason why such project is necessary in the national interest, or each such committee before the expiration of such 30-day period has notified the Administrator that no objection to the proposed action will be made.

Section 104

Section 104 would provide that, notwithstanding any other provision of this Act—

(1) no amount appropriated pursuant to this Act may be used for any program deleted by the Congress from requests as originally made to either the House Committee on Science and Technology or the Senate Committee on Commerce, Science, and Transportation,

(2) no amount appropriated pursuant to this Act may be used for any program in excess of the amount actually authorized for that particular program by subsections 1(a) and 1(c), and

(3) no amount appropriated pursuant to this Act may be used for any program which has not been presented to or requested of either such committee,

unless (A) a period of 30 days has passed after the receipt by the Speaker of the House, the President of the Senate and each such committee of notice given by the Administrator or his designee containing a full and complete statement of the action proposed to be taken and the facts and circumstances relied upon in support of such proposed action, or (B) each such committee before the expiration of such period has transmitted to the Administrator written notice to the effect that such committee has no objection to the proposed action.

Section 105

Section 105 would express the sense of the Congress that it is in the national interest that consideration be given to geographical distribution of Federal research funds whenever feasible and that the National Aeronautics and Space Administration should explore ways and means of distributing its research and development funds whenever feasible.

Section 106

This section would allow for the procurement of structural and component spares necessary for the efficient operation of the four-orbiter fleet as well as for maintaining production readiness for a fifth orbiter.

Section 107

This section would amend Title III of the National Aeronautics and Space Act of 1958 so as to give the National Aeronautics and Space Administration's name and initials protection against false advertising and related misues in essentially the same manner as the protection afforded the Central Intelligence Agency by Public Law 97-89. Similar protection is also presently provided to the FBI and a host of other agencies by 18 U.S.C. 709, the difference being that under this section (as under P.L. 97-89) the protection is obtained by civil proceedings in district courts to enjoin prohibited acts or practices rather than through criminal proceedings which could also involve fines and imprisonment, as is the case under 18 U.S.C. 709.

To this end, this section would prohibit the unauthorized use of the words "National Aeronautics and Space Administration" or the letters "NASA," including certain combinations, variations and imitations thereof, alone or in combination with other words or letters, in association with certain commercially oriented activities, in a manner that conveys a false or misleading impression with respect to some relationship or connection with, or support, sponsorship or endorsement of NASA. Such prohibition would apply to misuse of the NASA name both in association with a firm or business name and in connection with a product or service offered to the public. Prohibited acts and practices may be enjoined, or other corrective action taken, under a civil proceeding in a district court of the United States as the result of action initiated by the Attorney General.

NASA's technological success often catches the imagination of the general public, and association with this success can be commercially advantageous. In addition, NASA encourages the utilization of the result of its research and development activities; indeed, a number of technological developments and resulting new products and services available to the public can accurately and properly be related to NASA activities. Occasionally, however, NASA's name is misused in a manner that conveys a false or misleading impression regarding the relationship of NASA to a firm or business, or to a product or service made available to the public.

This misuse of the NASA name can be misleading to the general public and is unfair to those who properly utilize NASA developed or supported technology and accurately state their relationship thereto. In addition, where the practices of the party engaging in such misuses are questionable and the product or services provided are not what the public expects, the reputation of both NASA and those properly associated with NASA activities may suffer.

While this problem has been a continuing one since the existence of NASA, it is expected to become more acute as the Space Shuttle becomes operational and more opportunities are made available for its commercial use, either on a reimbursable basis or under a joint endeavor with NASA. It would be particularly unfair, for example, to those who have participated in such activities and through private investment have achieved commercial success, to have to contend with false or misleading statements of those who have not made such investments.

While presently unauthorized use of the NASA seal and certain official insignia and badges are subject to the penalties of 18 U.S.C. 1017 and 701, respectively, there is no mechanism for direct enforcement when unauthorized, false or misleading use of NASA's name or initials is found to exist in relation to a business or commercial activity. Corrective action requires investigations founded on unfair trade practices and/or the trademark laws, usually in conjunction with the Federal Trade Commission and/or similar state agencies. These investigations are difficult, time consuming, with the outcome often speculative. The opportunity for direct enforcement would be more prompt and sure, to the benefit of both the consuming public and the commercial competitors of those engaged in such unauthorized or misleading activities.

There are, of course, a number of authorized or proper activities in connection or association with NASA under which the NASA name may be used in an accurate, factual manner that does not create a false or misleading impression. There is no intent by this section to change NASA's policies, practices and procedures in this regard; but only to afford NASA better capabilities for corrective action in those instances where the NASA name is used in a manner reasonably calculated to convey the false or misleading impression of a relationship with NASA which in fact does not exist.

Section 108 expands the definition of the NASA administrator's responsibilities as found in the National Aeronautics and Space Act of 1958 to include the authority to operate the Space Shuttle, and related equipment and facilities.

Section 109

Section 109 would provide that the Act may be cited as the "National Aeronautics and Space Administration Authorization Act, 1984."

TITLE II

Section 201

Section 201 authorizes $29,336,000 for fiscal year 1984 to be used by the Secretary of Commerce to operate a civil land remote sensing satellite program including storage of a backup satellite.

Section 202

Section 202 stipulates that ownership or management of civil meteorological or ocean remote sensing satellites shall not be transferred unless the provisions of paragraphs 202(1) and 202(2) are fulfilled.

Paragraph 202(1) stipulates that the Secretary of Commerce shall not transfer ownership or management unless a statement of recommended policies, procedures, conditions and limitations for the proposed transfer is submitted to Congress.

Paragraph 202(2) requires transfer of ownership or management to be approved by law.

Cost and Budget Data

The bill will authorize appropriations for fiscal year 1984 in the amount of $7,205,100,000. In accordance with the requirements of Rule XIII, Clause 7 of the rules of the House of representatives, the Committees estimate for the next five years of NASA budget request is as follows:

Fiscal year:	
1984	$7,268,000,000
1985	7,028,000,000
1986	6,429,000,000
1987	6,393,000,000
1988	5,574,000,000

These estimates do not include provisions for any new program or program augmentation that may be recommended nor do they include any provisions for administrative adjustments that may be required.

Effects of Legislation on Inflation

In accordance with Rule XI, Clause 2(1)(4) of the Rules of the House of Representatives this legislation is assessed to have no adverse long-run inflationary effects on prices and cost in the operation of the national economy. NASA expenditures are labor intensive, with approximately 85 percent of spending directly for jobs and the remainder for materials. NASA employs about 21,000 civil servants and supports about 109,000 contractor employees, plus about 4,300 support services contractors. Assuming a multiplier effect of 2.5, the total, short-run employment effect on the United States' economy is about 336,000 jobs. This represents less than one-half of one percent of the total civilian labor force in the United States—too small to have a significant national effect, although there could be some specific cases of industry and regional employment and price changes influenced by NASA expenditures.

The most significant economic effects of NASA spending are long-run productivity advances from new technologies developed for the space and aeronautics programs. Many NASA sponsored advances in air and space and transportation, communications satellites, remote sensing satellites, and other innovations have improved the productive capacity of industry and stimulated the development and growth of many new businesses. These expanded business opportunities have and are expected to continue to stimulate more productive, non-inflationary private sector economic growth and job creation.

Although it is difficult to assess the results of the various macroeconomic studies of the effects of NASA spending on GNP, it is apparent from analyses done by the Midwest Research Institute, Mathematica, Inc., and others, that NASA high technology R&D expenditures have returned more to the economy in substantial and long-lasting productivity gains than has been spent. Since these gains are through spinoff commercial advances, they are "extra" returns above and beyond the primary goal of NASA programs: the successful completion of the various R&D mission assignments to meet pubic sector needs. Therefore, any gains which show positive economic returns in the long-run indicate a non-inflationary, significant return to the citizens of the United States.

CHANGES IN EXISTING LAW MADE BY THE BILL, AS REPORTED

In compliance with clause 3 of rule XIII of the Rules of the House of Representatives, changes in existing law made by the bill, as reported, are as follows (existing law proposed to be omitted is enclosed in black brackets, new matter is printed in italic, existing law in which no change is proposed is shown in roman: and large unchanged blocks of existing law is indicated by * * *).

National Aeronautics and Space Act of 1958, as amended:

* * * * * * *

DEFINITIONS

SEC. 103. As used in this Act—

(1) the term "aeronautics and space activities" means (A) * * * (B) the development, construction, testing, and operation for research purposes of aeronautical and space vehicles, [and] (C) *the operation of a space transportation system including the Space Shuttle, upper stages, space platforms, and related equipment, and (D)* such other activities as may be required for the exploration of space;

* * * * * * *

MISUSE OF AGENCY NAME AND INITIALS

SEC. 310. (a) No person (as defined by section 305) may (1) knowingly use the words "National Aeronautics and Space Adminstration" or the letters "NASA", or any combination, variation, or colorable imitation of those words or letters either alone or in combination with other words or letters, as a firm or business name in a manner reasonably calculated to convey the impression that such firm or business has some connection with, endorsement of, or authorization from, the National Aeronautics and Space Administraton which does not, in fact, exist; or (2) knowingly use those words or letters or any combination, variation, or colorable imitation thereof either alone or in combination with other words or letters in connection with any product or service being offered or made available to the public in a manner reasonably calculated to convey the impression that such product or service has the authorization, support, sponsorship, or endorsement of, or the development, use, or manufacture by or on behalf of the National Aeronautics and Space Administration which does not, in fact, exist.

(b) Whenever it appears to the Attorney General that any person is engagd in an act or practice which constitutes or will constitute conduct prohibited by subsection (a), the Attorney General may initiate a civil proceeding in a district court of the United States to enjoin such act or practice.

* * * * * * *

OVERSIGHT FINDINGS AND RECOMMENDATIONS

Pursuant to clause 2(1)(3)(A), rule XI, and under the authority of rule X, clause 2(b)(1) clause (3)(f), of the Rules of the House of Representatives no findings and recommendations are under consideration by the Committee on Science and Technology for inclusion in the legislative report to accompany H.R. 2065.

CONGRESSIONAL BUDGET ACT INFORMATION

This bill provides for new authorization rather than new budget authority and consequently the provisions of section 308(a) of the Congressional Budget Act of 1974 are not applicable. No authorization for State or local financial assistance is included in the bill.

ESTIMATE AND COMPARISON, CONGRESSIONAL BUDGET OFFICE

No information pursuant to Section 403 of the Congressional Budget Act of 1974 has been provided to the Committee on Science and Technology by the Congressional Budget Office as of April 15, 1983.

OVERSIGHT FINDINGS AND RECOMMENDATIONS, COMMITTEE ON GOVERNMENT OPERATIONS

No findings or recommendations on oversight activity pursuant to clause 2(b)(2), rule X, and clause 2(1)(3)(D), rule XI, of the Rules of the House of Representatives have been submitted by the Committee on Government Operations for inclusion in this report.

COMMITTEE RECOMMENDATIONS

A quorum being present, the Committee approved the bill by voice vote.

NASA RECOMMENDATIONS

This is a National Aeronautics and Space Administration legislation item approved with the exceptions noted in this report by the Office of Management and Budget, as indicated by the following letters:

FEBRUARY 25, 1983.

Hon. THOMAS P. O'NEILL, Jr.,
Speaker of House of Representatives,
Washington, D.C.

DEAR MR. SPEAKER: Submitted herewith is draft of a bill, "To authorize appropriations to the National Aeronautics and Space Administration for research and development, construction of facilities, and research and program management, and for other purposes," together with the sectional analysis thereof. It is submitted to the Speaker of the House of Representatives pursuant to Rule XL of the House.

Section 4 of the Act of June 15, 1959, 73 Stat. 75 (42 U.S.C. 2460), provides that no appropriation may be made to the National Aeronautics and Space Administration unless previously authorized by legislation. It is a purpose of the enclosed bill to provide such requisite authorization in the amounts and for the purposes recommended by the President in the Budget of the United States Government for fiscal year 1984. For that fiscal year, the bill would authorize appropriations totaling $7,106,500,000, to be made to the National Aeronautics and Space Administration as follows:

(1) for "Research and development" amounts totaling $5,708,500,000;

(2) for "Construction of facilities" amounts totaling $150,500,000; and

(3) for "Research and program management," $1,247,500,000.

In addition, the bill would authorize such sums as may be necessary for fiscal year 1985, i.e., to be available October 1, 1984.

The enclosed draft bill follows generally the format of the National Aeronautics and Space Administration Authorization Act, FY 1983 (P.L. 97-324). However, the bill differs in substance from the prior Act in several respects.

First, subsections 1(a), 1(b), and 1(c), which would provide the authorization to appropriate for the three NASA appropriations, differ in the dollar amounts and in some of the line items for which authorization to appropriate is requested.

Second, in addition to providing authorization of appropriations in the amounts recommended by the President in his Budget for fiscal year 1984, the bill also would provide authorization for such sums as may be necessary in fiscal year 1985. It is specified that all of the limitations and other provisions of the bill applicable to amounts appropriated pursuant to section 1 shall apply in the same manner to amounts appropriated pursuant to section 6.

Third, Title II of P.L. 97-324, which authorized the Secretary of Commerce to plan and provide for the management and operation of a civil land remote sensing space satellite system, has been omitted, since this title became law last year.

Fourth, section 7 is a new section implementing the President's policy at maintaining Orbiter production within the context of a four-orbiter fleet by allowing the procurement of structural and component spares.

Fifth, section 8 is a new section which would amend the National Aeronautics and Space Act of 1958 to protect NASA's name and initials from false advertising and related misuse.

Finally, the last section of the draft bill, section 9, has been changed to provide that the bill, upon enactment, may be cited as the "National Aeronautics and Space Administration Authorization Act, 1984," rather than "1983."

Where required by section 102(2)(C) of the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4332(2)(C)), and the implementing regulations of the Council on Environmental Quality, environmental impact statements covering NASA installations and the programs to be funded pursuant to this bill have been or will be furnished to the Committee on Science and Technology as appropriate.

The National Aeronautics and Space Administration recommends that the enclosed draft bill be enacted. The Office of Management and Budget has advised that such enactment would be in accord with the program of the President.

Sincerely,

JAMES M. BEGGS,
Administrator.

ADDITIONAL VIEWS OF HON. AL McCANDLESS

The Administration's budget this year reflected a recognition not only of the vital importance of a healthy aerospace industry to the security and economic well being of this nation, but also the necessity for strong government support of aeronautics R&D. Nonetheless, I support the shift of $22.7 million to civil aviation programs. The aviation industry has consistently provided a postive trade balance, however in recent years this trade balance has become seriously eroded. The risks of developing a new product in this industry are immense. Only one of every ten new aircraft is finacially successful. Yet, in spite of the risk, increasing numbers of countries, recognizing the many benefits to be gained, are joining with industry in challenging the U.S. position of leadership. Only by providing a better product can the U.S. aerospace industry hope to compete with the attractive financing and other subsidies offered by the consortiums of foreign governments.

The high risks and trememdous costs involved in developing the required new technology demand government participation, and I strongly support the NASA programs which will ultimately strenghten our civil aerospace industry. However, the aeronautics program that was approved by the Transportation, Aviation and Materials Subcommittee adequately funded these programs and I believe the Committee acted without justification in adding funding for which no need had been established.

AL McCANDLESS.

ADDITIONAL VIEWS OF HON. DAN GLICKMAN, CHAIRMAN, SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS

The Science and Technology Committee has proposed for fiscal year 1984 a budget of $311.6 million for NASA aeronautical research and technology. Although that represents an increase of $11.3 million over the Administration's proposal of $300.3 million, it barely brings us beyond the fiscal year 1980 expenditure of $308 million for aeronautics research and technology. Upon closer examination, the aggregate amount proposed for NASA aeronautics shows clear evidence of further withdrawal from key technological activities. In fact, in constant 1983 dollars, the fiscal year 1983 and 1984 aeronautics budgets are the lowest in 15 years.

During this era in which we are looking to advanced technology to act as a catalyst for economic modernization and job opportunities, it's high time that we put our money where our mouth is and fund a proven winner—aeronautics.

For over 65 years, since Congress created the National Advisory Committee on Aeronautics, the government has worked effectively with industry and labor to produce perhaps the most cost-effective advanced technology transfer program in existence. In fact, the total amount of money spent on aeronautics by NACA and NASA over their combined 65 years of operation is less than one-half of the value of our aeronautical exports in 1980 alone.

Yet, as we continue to be indifferent to the value of NASA aeronautical research to the American economy, we are increasingly faced with foreign government-subsidized competition which is jeopardizing America's historic leadership in aviation technology. The Ministry of International Trade and Industry of Japan has declared that the aircraft industry, along with computers, telecommunications and other high-tech fields, is one of the industries that Japan should focus on in the years ahead. The European Economic Community is already producing competitive aircraft. In fact, Europe's government-supported civil transport consortium, Airbus Industrie, sold more wide-bodied aircraft in 1981 (64) than all U.S. suppliers combined (43).

We can no longer expect that the American aviation industry will lead the world if we continue our policy of neglect or indifference. Clearly, we cannot afford continued complacency. The NASA aeronautics program has proven, time and time again, to be a cost-effective investment in America's future. We must renew our commitment to advanced aeronautics research if we are really serious about revitalizing the American economy.

DAN GLICKMAN.

ADDITIONAL VIEWS OF HON. WILLIAM CARNEY

The space program has probably been one of the most successful and popular programs in our history. NASA's achievements in space have been impressive, and NASA has enjoyed a reputation for producing results.

It's understandable that we're eager to support the very worthwhile goals of the program. And because of this success and the enormity and complexity of the space program, we have become complacent in exercising our responsibility to ensure that Americans get full value for their tax dollars. In fact there is an attitude prevalent on this committee that it is unpatriotic to question budget requests for space.

We can no more afford to throw money into space than we can afford to waste it here on earth. We have to start focusing on those activities that promise the highest returns on our space dollars. Moreover, there is an increasing concern that perhaps some of the vendors are getting too high a return on their dollars. I strongly recommend that we hold hearings soon to satisfy ourselves that the charges by some of these contractors are not only legitimate, but also reasonable, and that we are in fact getting our money's worth. The mysteries of space shouldn't blind us to the realities of exhorbitant costs.

William Carney.

ADDITIONAL VIEWS OF HON. BILL NELSON, HON. MANUEL LUJAN, JR., HON. ROBERT S. WALKER, HON. WILLIAM CARNEY, HON. RAYMOND J. McGRATH, HON. JOE SKEEN, HON. CLAUDINE SCHNEIDER, HON. HERBERT H. BATEMAN, HON. ALFRED A. McCANDLESS, AND HON. TOM LEWIS TO H.R 2065, NASA AUTHORIZATION BILL

In recent years, the Science and Technology Committee has expressed numerous concerns about the perceived "militarization" of NASA. Members have spoken out that the Department of Defense is taking over NASA, and that the civilian space agency subsidized the Space Shuttle to the extent that all other civilian space activities were substantially reduced. It is our belief that NASA has a defined responsibility to national security, and the agency should support DOD to the extent that DOD funds NASA.

In 1957 the American people were stunned by the successful launch of Sputnik I. The result was a stepped up American space program, increased emphasis on science teaching in our schools, and a renewed spirit of competition that the United States intended to win. When the first man in space was Soviet Cosmonaut Yuri Gagarin, the United States intensified its efforts. American astronaut Allan Shepard soon followed Gagarin. The President of the United States led the challenge by promising a man on the Moon by the end of the decade. Space was no longer science fiction.

Although the United States was the first and only nation to send men to the surface of the Moon and back, the Soviet Union did not slacken their space efforts. While the United States utilized the space program for scientific achievement and discovery, as well as military uses, the Soviet program was devoted almost entirely to military applications.

In the decade from 1960 through 1970 the United States surged in front in the area of space technology and achievement. In the past several years some areas of this dominance have seen some slippage. In some areas with possible military applications the Soviet accomplishments are alarming.

The purpose of at least 70 percent of Soviet space launches each year are military related. Another 15 percent is joint military and civil. The military related programs range from meteorological, communications, navigational, reconnaissance, surveillance, targeting and antisatellite missions. They also may be conducting military experiments on their manned space station flights, the longest of which has lasted 211 days. They are currently developing a heavy-lift space launch system which is comparable to Saturn V, that will be able to place payloads seven times greater than the U.S. Space Shuttle into orbit. Current evidence, recently declassified, shows that the Soviets are also developing a reusable space system similar to the shuttle and a small space plane. They have already conducted developmental test flights of the small vehicle.

In this regard, just a few weeks ago the Soviets recovered a space vehicle in the Indian Ocean that is believed to have been a test related to their shuttle development. These systems will further expand the military flexibility and capability of the Soviet space effort.

In 1977, the Soviets launched Salyut-6, a small space station complex. This space station, which remained in orbit until July 1982, demonstrated the capability to resupply and exchange personnel. These activities are now continuing on Salyut 7, which recently became the first modular space station which the Kosmos 1443 docked with the Salyut. This nearly doubles the size of the space station. On three occasions the Soviets have conducted manned missions lasting as long as six months, with the longest mission 211 days, almost three times greater than the longest 84-day manned U.S. mission in 1974.

The USSR has been rapidly developing a coordinated space weapons system involving the present generation of antisatellite vehicles (ASAT's), now operational and designed to destroy low-orbiting satellites. They are applying a very large, directed energy research program including the developing of laser beam weapons systems which could be based either in the USSR, aboard the next generation of Soviet ASATs or aboard the next generation of Soviet manned space stations. The ASAT system which is now operational has the capability to seek and destroy U.S. space systems in near-earth orbit. Although the system is limited in terms of the altitudes and inclinations of satellites it can attack, it poses a real and significant threat to our reconnaissance capability, and has forced the U.S. to develop our own ASAT capability to counteract that threat.

The Soviets have developed a system of radar ocean reconnaissance satellites which gives them a targeting capability for ships at sea that is superior to our own. Two of these nuclear reactor-powered satellites have also posed dangers to the world's populace by unexpectedly reentering the atmosphere (one in 1978 and the other just three months ago).

The majority of Soviet military space programs have been specifically designed to support terrestrial military operations. However, the development of an antisatellite system has extended Soviet military use of space to a capability for direct space warfare operations. It is important to re-emphasize the size of the Soviet program, demonstrated by a launch rate that is five times that of the United States, and the size of the annual payload weight placed into orbit, 660,000 pounds—ten times that of the United States. While these numbers do not take into account the technological lead we have which allows us to launch fewer satellites to accomplish the same purposes, they do clearly demonstrate the strong commitment of the Soviet Union to explore space to the maximum extent possible, especially for military purposes.

Therefore, we do not support the Committee view that NASA's role in national defense should be vigorously resisted. Granted, national defense responsibility belongs to the Department of Defense, however, NASA should support the DOD to the extent that DOD funds NASA. We firmly believe that NASA should not be constricted in their activities in national defense.

Bill Nelson.
Manuel Lujan, Jr.
Bob Walker.
William Carney.
Ray McGrath.
Joe Skeen.
Claudine Schneider.
Herbert H. Bateman.
Alfred A. McCandless.
Tom Lewis.

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